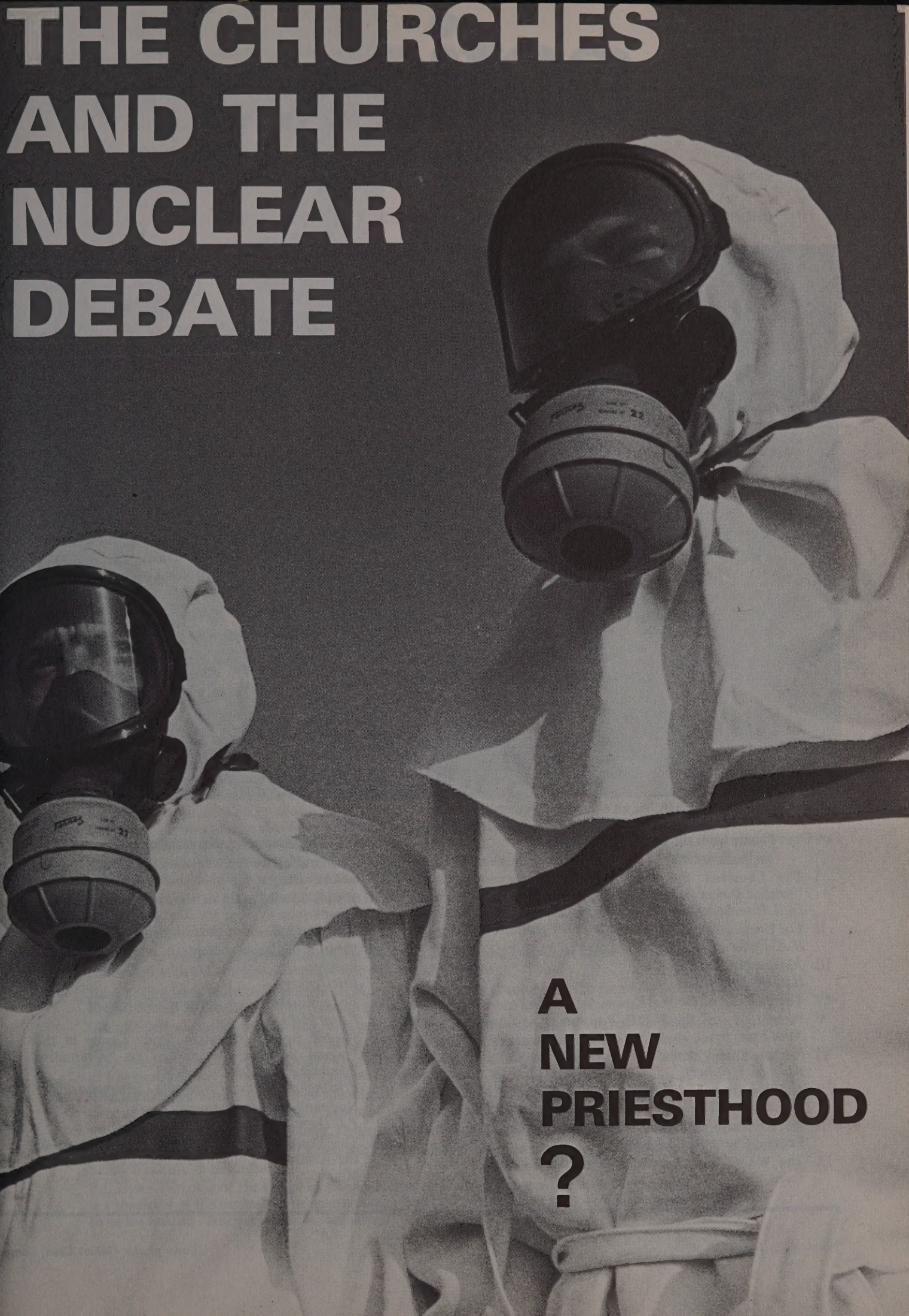
THE CHURCHES AND THE NUCLEAR DEBATE



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Part One: Papers from the Salzburg Conference on Nuclear Power

I The Churches and the Salzburg Debate on "Nuclear Power and its Fuel Cycle"
Paul Abrecht and David Rose 4

II For Nuclear Power
H.A. Bethe 8

III Against Nuclear Power
Hannes Alfvén 12

IV The Position of the W.C.C. 14

V Presentation of the W.C.C. Position at Salzburg
John Francis 19

VI Nuclear Energy at the Turning Point
Alvin M. Weinberg 22

VII A View from Outside the U.N. Conference – "Declaration for a Non-Nuclear Future" 26

VIII An Exchange of Views with a Critic from the Federal Republic of Germany 28

IX The W.C.C. and the Nuclear Debate – Next Steps 30

Part Two: The Concerns of Churches

I The Proliferation of Nuclear Technology
John S. Habgood, Bishop of Durham 33

II British Council of Churches Opposes Reprocessing Plant
G.S. Ecclestone and David L. Gosling 37

III Fruit of the Atom – Remarks on an Anti-Nuclear Position
Eric Jenkins 39

IV For a Moratorium – A French Viewpoint
Roger Mehl 42

V Report from a Christian Study Group in the Federal Republic of Germany on "Alternative Possibilities for Energy Policy"
Friedhelm Solms and Wolfgang Lienemann 43

VI Nuclear Waste Management
P.J. Dyne 46

VII The Position of the Executive Committee of the Australian Council of Churches on Uranium Mining 50

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Inside Cover: Plenary Session of the International Conference on Nuclear Power and its Fuel Cycle, sponsored by the International Atomic Energy Agency, Salzburg, May 2-13, 1977.

left: Dr John M. Francis who presented the WCC submission to the Conference.

THE CHURCHES AND THE NUCLEAR DEBATE

The nuclear debate continues and churches are being increasingly drawn into it. Judgements, opinions and questions multiply as more and more people discover the energy problem in particular. Already the debate has in many countries become polarized and the rival claims and counter-claims are often difficult to evaluate. This leaves many perplexed about the right course of action.

This issue of *Anticipation* makes available recent W.C.C. reflections on the nuclear issue as well as new and important contributions from churches, Christian study groups and individuals in different countries.

Part One consists of a selection of papers from the debate about Nuclear Power and Public Opinion at the International Conference on Nuclear Power and its Fuel Cycle, Salzburg, Austria, May 2-13, 1977. The W.C.C. contributed a paper and was also invited to chair the plenary session on this theme. Included here are:

- An evaluation of the Salzburg Conference by Paul Abrecht of the W.C.C. staff and David Rose, Professor of Nuclear Engineering at the Massachusetts Institute of Technology, and a member of the W.C.C.'s delegation at Salzburg.
- A paper *for* Nuclear Energy by noted nuclear physicist, Prof. Hans Bethe of the U.S.A.
- A paper *against* by the distinguished nuclear physicist, Prof. Hannes Alfvén from Sweden.
- The paper submitted by the W.C.C. on the Ethical Issues together with the 20-minute presentation of that paper to the Conference by Dr. John Francis.
- Lecture on "Nuclear Energy at the Turning Point", presented at the Conference by Dr. Alvin Weinberg, one of the pioneers in the development of nuclear energy in the U.S.A., now Head of the Institute for Energy Analysis, at Oak Ridge, Tennessee.
- The "Declaration for a Non-Nuclear Future" represents the views of a group opposed to nuclear energy and which met in conference prior to the U.N. Conference.
- A comment from an ecumenical colleague in the Federal Republic of Germany on the W.C.C.'s presentation at Salzburg, and our reply (a sample of the post-Salzburg debate!). Dr Altner is currently Professor at the College of Education in Koblenz. For two years he was working with FEST in Heidelberg.

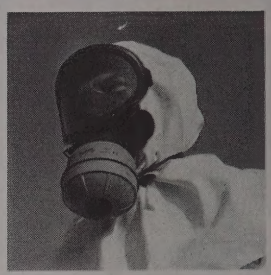
Part Two consists of statements and reflections by churches and individual Christian theologians concerned with the nuclear questions. The authors of these are:

- John S. Habgood, Bishop of Durham (U.K.), a scientist and a theologian. (His paper was presented to the British Group of the Council on Christian Approaches to Defence and Disarmament.)
- Giles Ecclestone and David Gosling, who presented the British Council of Churches' submission on the Public Enquiry on the proposal to build a reprocessing plant for waste nuclear fuel at Windscale in the U.K., are respectively General Secretary of the Board for Social Responsibility of the Church of England; and Lecturer in Theology (and former physicist) at Hull University.
- Eric Jenkins is a former member of the scientific staff of the U.K. Atomic Energy Agency and now Anglican vicar of Hightown, Liverpool, and Advisor on social and scientific affairs to the Bishop of Liverpool.
- Roger Mehl is Professor of Theology, Protestant Faculty of Theology, University of Strasbourg.
- Friedhelm Solms and Wolfgang Lienemann are members of the Team on Energy Studies for the Evangelical Study Institute in Heidelberg.
- P.J. Dyne, Director of the Office of Energy Research and Development in the Government of Canada, is a specialist in the nuclear waste management field and a churchman who has kindly made available to us his talk on "Nuclear Waste Management" which he gave in Canada in August 1977.

Paul Abrecht

PART ONE: PAPERS FROM THE SALZBURG CONFERENCE ON NUCLEAR POWER

I. THE CHURCHES AND THE SALZBURG DEBATE ON "NUCLEAR POWER AND ITS FUEL CYCLE"



PAUL ABRECHT AND DAVID ROSE

The International Conference on Nuclear Power and its Fuel Cycle which met in Salzburg, Austria, May 2-13, 1977, was, according to veteran participants, very different from previous U.N. sponsored scientific conferences on the Peaceful Uses of Atomic Energy. Gone were the glamour, the euphoria and the expectation which accompanied the early development of nuclear energy. Gone too were the days when a conference on nuclear power could confine itself to strictly technical questions. The nuclear power plants that currently feed energy into the electric power systems of many countries attest to the success of that previous concentration on nuclear technology. And it might seem that, at this moment of world concern over energy shortages, the achievements of nuclear energy would be welcomed as a replacement for dwindling fossil fuels. That welcome is however far from general. There is now a fuller awareness of the hazards that accompany nuclear energy and less certainty on how these hazards are to be contained within the physical and social structures of our world.

Hence in planning the Salzburg Conference, the International Atomic Energy Agency (IAEA), a U.N. body set up in 1956 to promote international agreements on the safe use of nuclear energy, sought to examine the continuing technical issues in the larger social and political context within which nuclear power must now be evaluated.

Discussions of world energy policy, proliferation, safeguards and public opposition to nuclear energy thus provided the background for the technical discussions of reactor design and security at Salzburg. And, although the 2,000 scientist-participants in the Conference were for the most part chosen by the 60 participating governments, the IAEA accepted a few non-governmental organizations, including the World Council of Churches, especially for the discussion of the social and ethical implications of nuclear power. Thus the W.C.C. became an accredited participant in this U.N. sponsored Conference and was invited to submit a paper on the ethical issues in the public acceptance of nuclear power. This eventually became one of three presentations in a plenary session on Nuclear Power and Public Opinion, which the W.C.C. was also invited to chair.

Nuclear Power and Public Opinion

The format of the discussion of nuclear power and public opinion was intended to assure a genuine facing of the issues: two Nobel Prize nuclear physicists – Prof. Hans Bethe of the U.S.A., speaking for the acceptance and further development of nuclear energy, and Prof. Hannes Alfvén of Sweden speaking against. That the exchange between these two distinguished scientists did not come up to expectations may be explained by a number of factors. The arguments on both sides are well known in these technical circles and neither speaker added substantially to the opposing views. Indeed the entire Conference was in various ways constantly struggling with the problem of public acceptance, and much of the argument had already been heard earlier in the Conference.

Judging from the technical parts of their presentations, it could be said that the difference between them was very small. Prof. Bethe recognized that various risks must still be overcome and admitted the need for carefully weighing different approaches to problems of reactor siting and safety, waste disposal, etc. And while Prof Alfvén defended the proposition that "nuclear technology – at least in its present form – is obsolete and should be phased out as soon as possible", he added the further thought that:

> *"However, we cannot exclude that a drastically different approach to nuclear energy might be successful. If nuclear scientists could mobilize enough initiative, competence and social responsibility for such a project this should of course be allowed to compete with other solutions of the energy problem, and should be judged in a fair and unbiased way. Such a project belongs to a rather distant future."*

The precise meaning of this paragraph remained a mystery and seemed to confuse his argument.

Yet in the final analysis their two positions were irreconcilable based as they were on very different views of the energy needs of the world in the coming decades. Prof. Bethe argued that nuclear power with all its dangers was necessary to provide energy as the fossil fuels are depleted;

Prof. Alfvén argued that with a proper use of alternative energy sources and "with a sound energy policy there is no risk at all that we shall be energy starved in the future".

Position of the World Council of Churches

The W.C.C. presentation addressed itself directly to the social and ethical issues posed by the expanding use of nuclear power. The W.C.C. paper represented the culmination of several years' work beginning with the 1974 Bucharest Conference on Science and Technology for Human Development. A two-page summary of the issues of Public Acceptance had been presented by the W.C.C.'s sub-unit on Church and Society to the August 1976 meeting of the Central Committee, which authorized Church and Society to make a submission to the Salzburg Conference on these lines. The full paper was drafted by Church and Society's Energy Advisory Group at a meeting in November, 1976, which in turn submitted its work for comment and criticism to the W.C.C. Executive Committee in February 1977.

Those familiar with the report of the 1975 Ecumenical Hearing on Nuclear Energy (Sigtuna, Sweden) and the 1976 Report on Energy for a Just and Sustainable Society (*Anticipation* no. 23) will recognize how the paper for Salzburg derives from the previous ecumenical evaluation of nuclear power. This paper sets out five considerations in terms of which a provisional ecumenical consensus about nuclear power appears to be developing. As summarized by Dr John Francis, the Christian layman and scientific consultant who made the presentation of the W.C.C. paper at Salzburg, these are:

(1) Nuclear energy offers the potential of providing a large part of the world's energy needs, counter-balanced by some exceptional risks. It would be politically naïve to think that nuclear energy will or can be abandoned.

(2) The maturity of the nuclear energy system is not yet such as to justify large-scale, or unlimited application; the consequences of further large-scale dependence need to be assessed.

(3) The right of access to nuclear technology must be recognized; the nuclear "haves" should not deny the nuclear "have nots" by any form of exclusive consultation.

(4) The issues of access and security involve the collective responsibility of all nations which needs to be assessed anew and administered through the IAEA, with more clearly defined functional objectives appropriate to the anticipated scale of the task.

(5) Public confidence in the use of nuclear energy, seriously shaken in recent years, can be revived only by the widest possible public discussion of the technical options and of the value judgements underlying present patterns of energy consumption.

The W.C.C. paper was much commented on at Salzburg and well reported and discussed in the secular and religious press after the Conference. In addition the Conference provided an unusual opportunity for the W.C.C. team to discuss the ethical and technical problems of nuclear energy with scientists and technologists from many countries.

The Nuclear Debate at Salzburg

The refusal to say an absolute "yes" or "no" to nuclear energy distinguishes the W.C.C. position from both those wholly in favour and those totally opposed to it. One of the most quoted passages in the W.C.C. paper is the statement that "Pandora's box cannot be closed. We cannot live as though nuclear energy had not been discovered." (Less noted is the further statement that "the wise use of nuclear technology depends paradoxically on a new understanding of human limits".)

A separate group of persons opposed to nuclear energy met prior to the main Conference at Salzburg, and produced a "Declaration for a Non-Nuclear Future". (The World Council of Churches was not invited to participate in their meeting.) Their statement called for the phasing out of all thermal reactors as soon as possible. It was distributed to the participants in the U.N. Conference, and the same group published a newspaper stating the arguments against nuclear energy. It was not very effective, despite an often lively style, perhaps because it was totally pessimistic about the ability of governments, individually or collectively, to control nuclear energy.

It is not surprising that those in favour of nuclear energy found the W.C.C. statement more acceptable. We found that most are prepared to discuss the risk and other problems of nuclear energy; but they believe that nuclear energy is economically viable and that it has been and can be used without problems where safeguards are respected. The nations represented at Salzburg did not feel they have the option of foregoing nuclear power. Spokesmen for the governments of the Federal Republic of Germany, Italy, France, the U.K., India, Pakistan, Iran, Brazil, Argentina, the socialist countries of Eastern Europe, and even the U.S.A., with some qualifications, made very clear that they intend to push ahead rapidly with the development of nuclear energy and the technologies required by the nuclear fuel cycle. Some countries, notably France and the Federal Republic of Germany, argued that they have no choice for the next few decades but to increase their use of nuclear energy as a way of reducing their dependence on imported oil and other fossil fuels. Any disinterested observer of the Salzburg discussion would, we think, agree that an increasing number of governments will, in response to the high price of oil, the desire for a greater measure of energy independence, and the need to avoid falling behind in the search for new technological breakthroughs on the energy front, turn to nuclear energy for part of their energy needs. This situation cannot be wished away, and it seems obvious that if the churches want to influence the debate about the responsible use of nuclear energy they will do well to maintain a critical position both against those who believe that nuclear energy presents no problem, and also against those who believe that nuclear energy can and should be totally phased out.

The determination of governments to proceed with nuclear power development and the growing opposition of some sectors of the public to this movement suggest increasing social tension and conflict in this area.

Is Nuclear Energy Contrary to the Will of God?

The question whether nuclear energy is against the will of God appears in many forms, even in U.N. circles! An issue of the U.N. sponsored newspaper *Development Forum,* published prior to the Salzburg Conference, included on the front page an article by the Swiss philosopher and theologian, Denis de Rougemont, entitled "Choice of Power and Power to Choose". He writes:

> *"It is as clear as daylight that the choice of nuclear power stations and retreatment plants for the infernal metal from which bombs are fashioned is daily increasing the risk of atomic war, or in other words, the end of the human race. It is no less clear that nobody*

has ever dared to state or even suggest that this option is the precondition of peace, inasmuch as it implies the end of our Nation-States, so bound up with the use of the well-named plutonium, that product of the underworld, and the advent of self-governing regions based on the resources of the sky, with its far reaching gaze towards Earth. ... Pluto is the lord of the shadows, he is as blind as a bat. But sunlight comes to us from the heavens, from Zeus, 'the far-seeing'."
(Development Forum, May 1977, Vol. V, No. 4, pp. 1-2)

It was not, we suppose, a pure accident that the editors of *Development Forum* published this attack on nuclear power just prior to the Salzburg Conference; and it is some indication of the state of affairs within the U.N. that no other information about the purpose and scope of the Salzburg Conference appeared in *Development Forum.* This is all the more remarkable in that the International Atomic Energy Agency is a specialized agency of the U.N. itself. Regarding the intellectual and theological context of such statements, we must turn back to the Middle Ages to find similar attributions of moral qualities to material substances. Christian, Jewish and Islamic scriptures clearly appoint God as the Creator of all that is, and Man as the responsible steward. No exceptions exist for specific elements or compounds, and man's success or failure to use things well cannot be fobbed off with the excuse of evil materials, any more than a bad workman can blame his tools. Whatever the intention of the editors, that *Development Forum* article is an appeal to pure prejudice and superstition against things under the earth as against things above.

(Since Salzburg some pastors have written us that the W.C.C. should encourage the use of God-given, natural elements like the sun and the wind, and not uranium, presumably not part of God's creation. Such judgements seem to us excuses to avoid thinking about the real and difficult problems of limits to growth, limits to energy use, the relation of nuclear power to international stability, the consequent value and costs of nuclear power to society, and so forth.)

Theologians in recent meetings to discuss the theological arguments for and against nuclear energy have been unable to conclude that there are specifically theological arguments against it. Yet Christian sentiment sometimes continues to oppose nuclear power on shaky logical grounds. As the Dutch Christian television interviewer said in questioning the W.C.C. delegation at Salzburg, "Since the W.C.C. is opposed to racism and militarism, why isn't it opposed also to nuclear power?" In his presentation of the W.C.C. paper to the Salzburg Conference John Francis spoke to this point: "The harnessing of nuclear energy is not an unnatural phenomenon, but rather an exceptional phenomenon capable of setting a unique challenge to the ingenuity and moral courage of people everywhere". Clearly there will need to be more mature discussion of the theological grounds for the evaluation of nuclear energy in the churches.

The Non-Proliferation Issue

The Salzburg Conference was especially concerned with the question of nuclear safeguards and the problem of limiting the spread of nuclear weapons. The proposals of President Carter for stopping proliferation provoked an immense debate. Probably no one disagreed with the intention of the American proposals but as presented they aroused much opposition and may have been counter-productive.

The American proposals included the following: in the interest of non-proliferation the U.S. would halt its own nuclear fuel reprocessing plans and stop construction of the first commercial breeder reactor. It would enlarge its facilities for the enrichment of uranium and promise fuel to those countries which joined the campaign against the world proliferation of the sensitive nuclear technologies, i.e. uranium enrichment, reprocessing and the breeding of plutonium.

To countries already dependent on American fuel for their reactors, this looked like prolonging the American monopoly of these strategic services. And it was argued that the decision of the U.S. to reduce its commitment to nuclear power was only possible because of resources of fossil fuels. Countries lacking such resources could not so readily de-emphasize the nuclear option.

The Salzburg Conference at this point became politicized, obliged to spend much time arguing the merits and demerits of the American proposals and various counter-proposals. Nuclear politics are not different from other international political discussions. It is a hard fought game and the interests of the different parties are not always clear. The opponents of nuclear power proclaimed President Carter a hero who correctly perceived the nuclear menace. For national governments the American decision threatened their future nuclear energy supplies. For many of the scientists much of the debate seemed beside the point since it was already too late to stop proliferation of technology that was already widely known and accessible to an increasing number of countries. To the officials of the IAEA the American proposals seemed to undermine efforts to build a truly effective international safeguards system.

However, the great confrontation between the U.S. and other countries was avoided. The American position softened and in the subsequent London summit conference President Carter accepted the right of the Western European governments to plan their own nuclear development according to their particular energy needs. Yet the critical question remains: can the nations, including the nuclear haves and the nuclear have-nots, agree on a means for international control of enrichment, reprocessing, and reactor development? The answer still seems far away and Salzburg's biggest contribution may have been to help countries see the urgency of the question.

Some Observations and Conclusions

When in 1976 the Central Committee voted to accept the Church and Society statement on Nuclear Power, it also recognized the need for "the further world-wide ecumenical debate on the technical, moral and spiritual issues posed by the expanding use of nuclear energy".

What are the next steps in this debate and how might the W.C.C. and the churches contribute their ideas and suggestions? Some major areas of concern are suggested by the Salzburg Conference and its aftermath.

1. The polarization in the debates is becoming greater. Because of intense feelings and suspicions aroused the anti-nuclear and the pro-nuclear views are tending to harden. The W.C.C. has not allowed itself to be drawn into an either-or position, to say an absolute *yes* or *no* to the maintenance or extension of nuclear energy. The reasons for this have been spelled out in a number of ecumenical papers beginning with the statement of the Hearing at Sigtuna in 1975 which affirmed that "we would not feel justified in either entirely rejecting nor in whole-heartedly recommending large-scale use of nuclear energy".

2. We feel that the debate about nuclear energy is, ethically speaking, not like the debate about racism, which practically all churches opposed, but more like the debate about abortion or war in which it has never been possible for most of the churches to take an absolute position for or against, but in which everything hinges on the way it is used.

3. The W.C.C. has a responsibility, in cooperation with international bodies like the International Atomic Energy Agency, to continue to reflect on the social and political issues provoked by world-wide nuclear energy development, and to press the search for and implementation of just and acceptable solutions.

4. The W.C.C. also has a responsibility to debate these issues both with those who are totally opposed to and those who are totally in favour of nuclear energy, all of whom often reflect concerned Christian opinion.

5. Many national and local churches have become actively involved in the discussion of nuclear energy policy. Others are still unclear about their role. The W.C.C.'s programme needs to take into account the experience of these national and local churches.

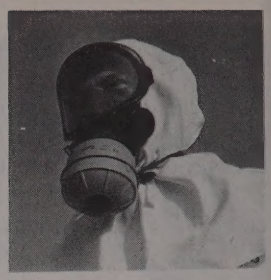
6. The nuclear debate is still a very Western debate. Third World countries with the possible exception of India, Brazil, Japan, Egypt, Iran and a few others, are scarcely heard from. It is dangerous that international decisions on such a vital issue should be taken without more participation on their side. The W.C.C.'s programme needs to help ensure that their views are heard.

top left: *Prof. Hannes Alfvén (Sweden) who spoke against nuclear power.*

above: *Prof. Hans Bethe (USA) who spoke for nuclear power.*

left bottom: *Presiding over the plenary debate on Nuclear Power and Public Opinion. Left to right: M. Georges Delcoigne, Public Information Section, IAEA; Dr Paul Abrecht of the WCC; Mr. R. Skjöldebrand, Scientific Secretary, IAEA.*

II. FOR NUCLEAR POWER



The Controversy About Nuclear Power

H.A. BETHE

1. The Fight for Public Acceptance in the U.S.

In the last several years there has been a hard battle on the acceptance of nuclear power in the U.S. Innumerable anti-nuclear books have been published, each more strident than the other. In a recent exhibition sponsored by students of Cornell University I counted about 20 such books. One-sheet appeals are often even more extreme. The media have shown a bias against nuclear power; this includes our most prestigious newspapers, as well as the major TV networks and so-called "public" (i.e. not commercial) television as well.

On the other side, there is at least one good pro-nuclear book by Fred H. Schmidt and David Bodansky, *The Fight over Nuclear Power.* This gives a very calm and clear assessment of the problems, understandable for the educated laymen. I can recommend it to those who, in Europe and other countries, wish to talk about nuclear power. Another very good account is the pamphlet *Nuclear Energy and National Security,* by the Committee for Economic Development, New York. It endorses nuclear power as necessary for the economy of many countries around the world, and at the same time recognizes the problems, especially that of proliferation of nuclear weapons. Also useful is *The Nuclear Controversy,* published by the American Assembly of Columbia University, which includes a well reasoned anti-nuclear contribution by G.B. Kistiakovsky. Finally, for a comprehensive discussion of the plutonium problem, I have found most useful the publication by EPRI (Electric Power Research Institute), Report EA-43-SR, entitled *Plutonium: Facts and Inferences.*

In 1975, the opponents of nuclear power introduced bills into several state legislatures to block construction of further nuclear plants and (in some cases) operation of existing ones. In the U.S., the individual states have jurisdiction over the use of the land, including the siting of nuclear and other power plants; they can forbid the introduction of materials injurious to health, etc. It is on this right of the states that the anti-nuclear bills were trying to build. In some cases, these bills might have come in conflict with the Federal Government's pre-emptive right to regulate nuclear energy. In any case, in hearings before the state legislatures, the supporters of nuclear power generally presented a more convincing case, amply supported by written evidence. These hearings frequently go rather deeply into the subject, so logical and numerical arguments can be brought out and discussed. Undoubtedly, the staff of the legislators studied the written evidence in detail, and the legislators themselves were aware of the economic needs of their states. As a consequence, most of the bills were defeated, and only a few pieces of anti-nuclear legislation were actually passed.

Having been unsuccessful with the legislatures, the opponents of nuclear power turned directly to the people. In many states in the U.S., it is possible to introduce "initiatives" to be voted on directly by the voters, in connection with a general election. Such "initiatives" were introduced in the states of California, Arizona, Colorado, Montana, Ohio, Oregon and Washington. The California initiative was voted on in June, all the others in November 1976.

The initiatives were cleverly phrased, purporting to aim for increased safety of nuclear power plants. Only if you read the lengthy proposition in detail (which very few voters did), and penetrated through the complicated legal language, could you find out that they in fact aimed at stopping construction of new nuclear plants, and in some cases, notably California, a gradual closing down of the existing ones.

The battle was hard fought. The arguments were generally on a low level and highly emotional. One of the most active groups in California called itself "Project Survival", claiming that the radioactivity produced by nuclear reactors would, in some manner, kill all life on earth. Frequently, nuclear power was equated, explicitly or by implication, with nuclear weapons actually used in war. Quantitative arguments were disregarded, not only by the public speakers, but by the numerous prominent scientists who lent their names to the anti-nuclear groups. On the other hand, a still larger number of equally prominent scientists, not connected with the nuclear industry, spoke out and wrote in favour of nuclear power, pointing especially to the economic need for energy.

The supporters of nuclear power can be quite satisfied with the out-come of these "initiatives": all of them were defeated, mostly with a majority of 2 to 1. However, undaunted by these defeats, the anti-nuclear groups are preparing to introduce further initiatives. A second initiative is planned in Oregon, which reportedly proposes not only to stop further nuclear power plants in that state, but also to close down an existing one, the Trojan plant near the mouth of the Columbia River which supplies electricity to the state of Washington as well as Oregon. Also an initiative is planned in Maine.

After the vote, the anti-nuclear groups claimed that their initiatives were defeated by the larger amount of money spent in propaganda against the initiatives by utilities and nuclear equipment manufacturers. On the other side, one must consider the enormous volunteer effort which the anti-nuclear groups mounted. In California this had gone on for about a year and a half, and involved many thousands of volunteers, holding public meetings as well as house-to-house campaigns. If a reasonable value is put on the time of these volunteers, it would surely amount to many millions of dollars; in addition, the news media reported these efforts prominently, in effect giving free advertising where the industry had to pay. The fight became bitter and near the end of the campaign the industry also had a lot of volunteers; many of their employees willingly gave their free time to present the case for nuclear power, as did many scientists outside the industry. But their numbers never equaled those of the anti-nuclear groups.

As far as I can see, the anti-nuclear initiatives were defeated by the fact that the pro-nuclear group had the better arguments. The most effective argument was the coupling between energy and GNP, and especially the coupling with jobs. For the latter reason, the labour unions were strongly in favour of keeping and expanding nuclear power. Construction and electrical workers were of course in the forefront, bur also other unions joined in. In fact, the most rousing speech in favour of nuclear power that I have heard was presented by a labour leader during a large conference on energy in general. It seems to me important for the friends of nuclear power in other countries to get the complete backing of labour.

Not only were the initiatives voted down in the respective states, but also a nation-wide inquiry conducted by the Harris poll gave the same result. People across the nation voted approximately 2 to 1 in favor of extended use of nuclear power. In comparison to a similar poll a year earlier, a larger fraction of politicians were also backing nuclear power.

The battle over nuclear power is far from over in the U.S. Presently the chief attack is made through the law courts. Swayed by the arguments presented by very clever lawyers, at least two U.S. courts have put major obstacles into the licensing procedures for nuclear plants. Stated in somewhat exaggerated form, the argument is that power plants should not be licensed until the entire fuel cycle is decided upon and its feasibility proved. At the same time, anti-nuclear groups have argued successfully that the U.S. should not permit operation of a chemical reprocessing plant which means that the fuel cycle cannot be closed.

However, there are also some favourable signs. For instance, the *New York Times,* in a recent article, for the first time considered nuclear power as a matter-of-fact component of the total energy structure of the country.

Most of us welcome public debate, but a debate conducted with rational arguments, not with vast exaggerations, especially of the dangers, as has been the case too often in the U.S. I am particularly happy that another speaker today is Dr. Abrecht of the World Council of Churches. The study which the World Council of Churches published on the problem of nuclear power is a beautiful example of bringing out the arguments on both sides, and asking searching and pertinent questions. The nuclear community must investigate and answer these questions. A dialogue of the type initiated by the World Council of Churches, and a wide public discussion on this level, can only be helpful to all concerned. I have great confidence that such a dialogue will clarify the issues.

2. Some Arguments against Nuclear Power

I shall take up only a few of the arguments which have been prominent in the discussion.

Safety of nuclear power plants

The basic reference here is the *Reactor Safety Study* known also as the Rasmussen Report and as Wash-1400. It was originally commissioned by the U.S. Atomic Energy Commission; a draft of the document was published in August 1974 and the Commission invited the public to comment on it before a final document would be drawn up. Among the comments was a rather severe, book-length critique by the Union of Concerned Scientists; this was in turn rebutted in detail by Dr. Døderlein of Norway who is here. The American Physical Society criticized essentially only one point in the Rasmussen draft report, namely the treatment of long-term effects of the radioactivity which might be released in a hypothetical reactor accident. This criticism was accepted by the Rasmussen group (with some modification) and incorporated in the final report Wash-1400, published by the successor to the AEC, the Nuclear Regulatory Commission, in October 1975. This report was in turn criticized, among others by Dr. Yellin of MIT, and Yellin's paper in turn was answered by Richard Wilson of Harvard. In this manner the problems have been batted back and forth, and I believe this is good though time and energy consuming. I believe the most difficult remaining problem is the assessment of the probability of common-mode accidents. On the whole, my feeling is that the Rasmussen assessment of accidents is good, in some cases too optimistic, but in other cases pessimistic.

Research on safety of nuclear reactors continues with increased financial support in the U.S. In particular, the LOFT facility is running, and giving satisfactory results about the effectiveness of the Emergency Core Cooling System. At Brookhaven National Laboratory and at the Los Alamos Scientific Laboratory extensive calculations are being made, which I am confident will permit the extrapolation from LOFT to a full scale facility.

Waste disposal

As far as I can see, a number of good solutions of the waste disposal problem have been formulated but none has yet been put into practice. The scheme of transforming the waste into borosilicate glass, of which I have a sample here, seems to me very good. This glass is very tough and resists leaching by water, possibly for centuries. Some further questions remain to be answered, e.g., whether the glass will be affected by the chemical transformation of the metal ions inside it due to radioactive decay. As far as I understand, to make this glass, the fission products must be in an acid solution which can be done in future chemical processing. A method still has to be found for disposing of the fission products now in neutral or basic solutions which resulted from previous chemical processing.

For a final disposal of the waste, the favoured method in the U.S. is burial in salt beds about 600 meters below the surface. This seems to me a good method, and the U.S. is fortunate in having over 100,000 square kilometers of salt beds. It may be an important problem for Europe and other countries to search for suitable salt beds or other stable, geologic formations. It is believed that many other formations are also suitable, e.g., shale and granite. Also we may try to learn from nature's beautiful experiment in Oklo, Gabon, where nuclear wastes including plutonium remained undisturbed for nearly 2 billion years.

Waste disposal deserves close attention by the best scientists, but it seems to me a technically soluble problem.

Safeguards against diversion of material

It is essential that any material produced in the nuclear fuel cycle which might be used maliciously to do damage to society be carefully controlled. The Sandia Laboratory of ERDA has worked for many years on the prevention of theft of nuclear weapons, and more recently of nuclear materials. I believe their work has been excellent. They have developed methods for safe and secure transport of nuclear materials in specially designed trucks or railroad cars which seem to me indeed very secure against hijacking. Similarly, they have methods for the protection of stationary facilities, particularly chemical reprocessing plants and refabrication plants for nuclear material. The protection is a combination of ingenious technical devices and security guards. I hope and I believe that Sandia will make these methods available to other countries who wish to protect their own nuclear plants; it is in the interest of all of us that this protection be effective.

Protection against clandestine diversion cannot be achieved by any accounting method now known. Losses of

materials in chemical processing and similar procedures are too great. The only satisfactory protection is to insure that no plutonium or other fissile material leaves the chemical plants without authorization. Fortunately, plutonium emits characteristic gamma rays. The Los Alamos Laboratory, and a group at Brookhaven, have developed a device to screen all people who leave a plant in which plutonium is manufactured. This device, similar to the metal detectors used for screening passengers at airports, will detect amounts of plutonium of 1 gram and possibly less.

It is evident that all persons working in nuclear plants, particularly chemical reprocessing and fuel fabrication plants, must be carefully selected for their loyalty and reliability. This may conflict with certain standards of civil liberties existing in the western democracies, and particularly in the U.S. However, it seems to me that the safety of the citizens of the country at large must have priority over any extreme interpretation of the civil rights of the relatively few people involved in nuclear facilities. Security clearances, similar to those for persons working on nuclear weapons, and those for military personnel working in sensitive military installations should be applied to persons working in sensitive nuclear plants like chemical separation and fabrication of fuel containing plutonium. Operators and engineers working inside power reactor buildings should probably come under the same regulations. By careful screening of this personnel it should be possible to avoid theft of plutonium, and hence avoid infringement of the civil rights of the population at large in a possible search for lost nuclear materials.

3. Proliferation

Over the last two years, the problem of proliferation of nuclear weapons has become increasingly prominent in public discussion. Among the most reasonable critics of nuclear power, and also among many people who fully support nuclear power in its present form, the fear has been expressed that widespread use of nuclear power will lead to diversion of plutonium by some countries, and the subsequent manufacture of nuclear weapons by them. This problem is prominent in the pamphlet by the Committee for Economic Development, in the published papers by the World Council of Churches, and in the advance outline of the paper by Dr. Abrecht.

The fear is particularly great with regard to breeder reactors which, as is generally assumed, will be an essential component of nuclear power in the longer run. This fear of proliferation has induced President Ford to declare a three-year moratorium on the operation of the chemical reprocessing plant built by Allied Chemical and Gulf Oil at Barnwell, South Carolina. The fear is that once plutonium is separated from the radioactive fission products, it could become a tempting material for the manufacture of bombs.

It is obviously most important to make the benefits of nuclear power available to all nations that need it, and at the same time prevent the proliferation of nuclear weapons. Both of these aims are prominent in the Non-Proliferation Treaty, and are the main task of the IAEA. Because public acceptance of nuclear power is so closely related to this problem, I shall spend much of the remainder of my talk on it.

1. The decision to develop nuclear weapons is clearly a decision for each individual country. However, I believe that the idea of the nuclear Non-Proliferation Treaty (NPT) is sound. Any given country will be more secure if it can be assured that its neighbours do not have nuclear weapons, than if it itself develops such weapons and its neighbours do as well. The NPT is primarily a protection of the smaller countries, not of the great powers, even though the two "super powers" have been most instrumental in bringing the treaty about. It does not constitute much direct danger to one of the super powers if a small country acquires a few weapons, but it does constitute a great danger to the possibly unfriendly neighbours of that country. Nevertheless, I believe that the super powers should also fulfil their part of the NPT, and proceed with actual reduction of nuclear arms including a complete cessation on nuclear weapons tests. President Carter has publicly supported this idea.

Regardless of the NPT, a really determined country can still acquire nuclear weapons. The only thing that the world at large, and IAEA in particular, can do is to make this acquisition more difficult, so that real determination is required, and a country does not slide into possession of nuclear weapons just because it is so easy to get them and "might be nice". Also IAEA can provide signals that a given country is indeed embarking on a nuclear weapons programme, giving other countries time to react.

2. If a country wishes to make nuclear weapons, the ideal substance is of course U-235 because it is far easier to make weapons from this substance than from plutonium. The second choice would be weapons-grade plutonium, i.e. plutonium which has been in a reactor only briefly. Only the last resort would be real reactor plutonium, because of its high content of Pu-240 which tends to make a weapon predetonate before it is fully assembled.

No doubt bombs can be made from reactor plutonium. If they are well designed and built they will explode. In spite of the Pu-240 content, the weapon will have a certain minimum yield if the neutron initiating the chain reaction arrives exactly at the moment in the implosion when the plutonium reaches criticality. If the initiating neutron arrives later, the yield will be higher. The probability of achieving more than minimum yield, and the minimum and maximum yield themselves, depend sensitively on the design of the weapon, in particular on the amount of explosive. If the bomb is designed sufficiently conservatively so that the designer can be confident that it will work, and if at the same time it is to be easily deliverable (i.e. have moderate weight), neither minimum nor maximum yield will be very high. Even the maximum will be well below the Hiroshima bomb. Whether such a device is attractive to the military of any country, I do not know.

In all countries which so far have developed nuclear weapons, thousands of scientists, engineers and technicians were employed in this endeavour, beyond the production of material. In a pinch, and for the development of only a crude bomb, a much smaller number of very highly trained people will suffice. This matter is discussed in some detail in the book *Plutonium: Facts and Inferences,* in Chapter 5. Perhaps the most reasonable minimum estimate is 6 persons highly trained in different subjects.

3. Even though the building of an atomic bomb is not as easy as many people seem to believe, the primary safeguard against the building of bombs remains unavailability of plutonium. Nations will feel assured of non-proliferation only if plutonium remains as unavailable as possible. To assure such unavailability was the de facto intent of the three-year moratorium on fuel reprocessing in the U.S. declared by President Ford in October.

Mutual agreement must be reached between vendors and customers in the peaceful nuclear energy trade. I was very encouraged recently when France and West Germany declared their intention to join the other nuclear vendors in prohibiting the sale to other countries of chemical reprocessing and isotope separation plants. It is most important that the customer countries also understand the wisdom of this policy. It is an extension of the non-proliferation idea which, as I mentioned before, benefits small countries at least as much as large ones. If a country does not have reprocessing and isotope separation plants, its neighbours and the world

will have assurance that it cannot suddenly confront them with the accomplished fact of an atomic bomb. I believe IAEA is in favour of establishing regional reprocessing plants under international control, an idea which appears to me also to be very good. Another suggestion has also been made, namely that the nuclear fuel be only leased to the customer, with the condition that it has to be returned to the vendor for reprocessing. Of course, the manufacturers of nuclear power plants must undertake an obligation on their part; they must guarantee an assured supply of nuclear fuel to their customers. Unfortunately, the U.S. has not been very consistent in this matter.

4. It has often been stated that the availability of plutonium will be substantially increased when breeder reactors become a major part of the nuclear power establishment. This is correct, but the quality of the plutonium from spent breeder fuel is no better than from a light water reactor, i.e. it contains a similar percentage of Pu-240. An exception is the radial blanket of the breeder but this contains only a few percent of the plutonium, and is likely to be processed only rarely.

It is agreed that breeder reactors are essential for the long term future of nuclear power. The problem is how to reconcile this with the desire to prevent proliferation. An important step in this direction is the suggestion in the article by T.B. Taylor and H.A. Feiveson in the December 1976 issue of the *Bulletin of American Scientists.* Their proposal is essentially as follows:

The nuclear energy establishment would consist of two components. One is a set of thermal neutron reactors working on the thorium cycle. The second is a much smaller number of fast breeders. These would use plutonium and U-238 in their core, with enough breeding ratio to sustain the reactivity inside the core. The blanket of the breeders would be made of thorium so as to produce U-233 for the thermal reactors.

It is desirable to have many more thermal reactors than fast breeders. To achieve this, a very high conversion ratio in the thermal reactors will be necessary. This points almost uniquely to heavy water reactors, perhaps of the Candu type. Taylor and Feiveson propose that in these thermal reactors the ratio of U-233 to U-238 to thorium be about 1 to 6 to perhaps 50. Then in the thorium U-233 will be bred, while in the uranium a small amount of plutonium will be formed. The ratio of U-233 to U-238 is chosen in such a way that even after the uranium is chemically separated from thorium (and plutonium and fission products), it still will not be suitable for nuclear weapons. The amount of plutonium bred would be much smaller than that presently produced in light water reactors, perhaps 20%. This plutonium would be separated from the uranium and thorium, and would then be fed back into the breeder reactors. Only the thermal reactors would be sold in international trade.

The breeder reactors ideally would be under international management. They would presumably be located in countries of the greatest internal stability. I would suggest that the plants for reprocessing of breeder blanket fuel be located in close proximity. The fuel which would leave these plants for use in international trade would be already mixed, containing 233 and 238 in the ratio 1 to 6, so it could never be used for bombs.

Obviously in the early stages the fuel in the heavy water reactors would be U-235, and only gradually would this be converted to U-233. It is clear that we would have to learn chemical separation of fuel containing thorium, uranium and some plutonium. The use of U-233 would also require remote handling of the fuel which would involve added expense, but also added protection against theft.

5. Any type of nuclear economy which permits large-scale power production but seeks to prevent proliferation of nuclear weapons will always mean a conflict between the aims of world peace and national sovereignty. This is even true of the Taylor-Feiveson proposal although this proposal minimizes the conflict. In my opinion, this conflict must be resolved in favour of world peace, just as in the safeguards problem inside a nation the resolution has to be in favour of public safety and involves some abridgement of the civil liberties of the guards and other persons involved in the nuclear establishment.

4. Conclusions

Exaggeration, demagoguery, and emotionalism have characterized the nuclear debate. They will get us nowhere. On the other hand, I welcome a factual public discussion on a broad basis. This discussion must include the economic issues; it must be realized that there is a continuing energy crisis, that oil is indeed running out and must be replaced by other energy sources, that most of the alternatives proposed will not work or not be economical, or may only work in the distant future.

Energy presents many technical problems. Some of these are soluble, like that of nuclear waste disposal. But there are also problems insoluble by foreseeable technology, such as making large amounts of energy from solar heat in an economic manner. The public should not demand that technology solve the insoluble problems. They should trust the judgement of the scientists and engineers on which problems are soluble and which are not. They should trust them also to solve in time those problems which are considered soluble, and not demand that all problems of nuclear energy be fully solved *before* the first plant is put into action.

Some problems are not technical, but require international understanding and cooperation. Nuclear weapons proliferation is an outstanding problem in this category. But technical ideas can at least help in a solution, such as the Taylor-Feiveson proposal for a combined thorium-plutonium economy.

III. AGAINST NUCLEAR POWER

ENERGY POLICY AND PUBLIC ACCEPTANCE

HANNES ALFVÉN

1. The Development of Nuclear Energy

The bombs at Hiroshima and Nagasaki demonstrated to the world what a horrible weapon of mass destruction had resulted from the discovery of nuclear fission. But it was generally hoped that the same process could also be used for giving the world a clean, cheap, and virtually unlimited source of peaceful energy. Around 1950, intense work on the development of this energy source was in full swing.

Certainly it was understood that some dangers were associated with it; its connection with atomic wepons was obvious, but it was believed that peaceful and military nuclear energy could be separated. In fact, the NPT and the organization of IAEA was an attempt to keep them separated. Further, it was feared that radioactive substances which necessarily are associated with nuclear energy would constitute a threat to our environment, but waste and environmental questions were almost never discussed at that time, so not very much attention was paid to this. It was already then believed that these problems could easily be solved in the future.

In 1960, ten years later, the future of nuclear energy looked very promising. A number of countries had started large nuclear programmes.

2. The Environmental Movement

At the same time, but independently, another factor in the development of society became of importance, namely a more reserved attitude towards technical development and industrialization. The bright picture of science, technology, and industrialization ushering us into an era of prosperity and happiness became tarnished when too often it appeared that the result was an unacceptable deterioration of the environment. This gave rise to the environmentalist movement.

In the beginning industrialists looked down upon the environmentalists, and considered them to be ignorant and in particular "emotional". In the debates it was easy for the industrial establishment to get the upper hand by focussing the discussion on technical details, unfamiliar to the environmentalists.

However, a new phase soon began when environmentalists began to study the industrial processes and their complicated impact on the environment. An increasing number of environmentalists became at least as knowledgeable as industrialists, even down to the details of the complicated processes. This gave another character to the debate and transformed the grass-root movement into a factor of political significance.

The official recognition of this came with the U.N. Conference on Environment in Stockholm in 1972. This was of course also an attempt to incorporate the environmentalist movement into the establishment. However, during their fight the environmentalists had become so suspicious of the establishment that the attempt was only partially successful. The environmentalists continued to have an anti-establishment attitude, which kept the movement alive. Their influence on public acceptance of energy policies seems still to be increasing.

3. Criticism of Nuclear Energy

Initially, the attitude of environmentalists towards nuclear energy was ambiguous. The nuclear industry presented it as a "clean" energy: no smoke, no visible water pollution. However, an increasing criticism of nuclear energy was voiced by a number of competent scientists, especially biologists, and around 1970 it became obvious to every unbiased and knowledgeable observer that criticism must be taken seriously.

The environmentalists began to understand that the nuclear energy constituted a serious threat to human ecology. The nuclear establishment realized very early how serious the criticism was and that an open discussion would be dangerous. Hence it made strong and persistent efforts to suppress the criticism and to avoid an open discussion. For example, at the Stockholm Conference 1972 the nuclear establishment stopped all criticism of nuclear energy and instead proclaimed nuclear energy a saviour of mankind. It was recommended as the solution of all the energy problems, not least in the developing countries.

Since then, however, the opposition against nuclear energy has avalanched and is now so powerful as to be of serious concern to the nuclear industry. In part, this is due to the way the nuclear establishment has responded to criticism. It is possible that the Rasmussen report has been more devastating to the credibility of the nuclear establishment than *We nearly lost Detroit.*

When the social and political consequences of nuclear energy became obvious, a number of scientists and technologists who worked in the nuclear establishment reacted and began to voice criticism. Their competent and devoted contributions often put them into a very difficult situation, but largely thanks to their work it is now possible to evaluate nuclear energy from an unbiased point of view.

4. The Main Objections

As we all know, the main objections against nuclear energy are:

A. It is necessarily associated with the production of enormous quantities of radioactively poisonous substances, and unfortunately it is far from obvious that these can be kept under control.

B. The coupling between nuclear weapons and "peaceful" energy is so strong that we have to accept both or neither.

C. It is becoming difficult to support the claim that nuclear energy is cheap.

D. There are several other and more attractive ways of solving the energy problems.

At least in several countries the nuclear establishment has no longer the power to suppress the development of

alternative solutions of the energy problem, or an open discussion. Hence the nuclear industry must necessarily solve the points (A), (B), and (C) in order to be publicly acceptable. This is a formidable task. Even if many of us hope that it will succeed the prospects seem not to be very favourable. The conclusion is that nuclear technology – at least in its present form – is obsolete and should be phased out as soon as possible.

However, we cannot exclude that a drastically different approach to nuclear energy might be successful. If nuclear scientists could mobilize enough initiative, competence, and social responsibility for such a project this should of course be allowed to compete with other solutions of the energy problem, and should be judged in a fair and unbiased way. Such a project belongs to a rather distant future.

Hence, the present most important energy problem is what the new non-nuclear energy mix should be and to consider whether it is publicly acceptable.

5. Money and Scientific Progress

A very important feature of the scientific-technological development is seldom mentioned. The general belief is that if politicians and industrialists pour money into a certain field this field will develop in proportion to the amount of money supplied. This is not correct. Money is a *necessary condition* but not a *sufficient condition* for progress. Another, perhaps even more important, factor is that a field must be challenging and fascinating enough to attract brilliant people who can use the money in a sensible way. If this condition is not satisfied, no flood of money can produce very much progress.

From the discovery of fission up to around 1970 nuclear energy had challenge and glamour enough to attract brilliant scientists and technologists. But this era has passed – probably forever. The best young students do not go nuclear any more, and many of those who are already in the nuclear trade switch over to other activities if they can – and the best people usually have this possibility. Alternative energy sources have now taken over an increasing share of the old glamour of nuclear energy, and there is an upsurge of new ideas on how to solve energy problems in a non-nuclear way.

This is important because it means that as time goes on it will be increasingly difficult to solve those remaining problems in nuclear energy which are not solved already. It is, for instance, often claimed that reactor safety and waste disposal problems will be more or less automatically solved with increased experience. However, one should keep in mind that these extremely sophisticated and difficult problems are now coming in the hands of people who often do not belong to the elite which developed the nuclear technology in the past. In fact it was in part this elite which early discovered the dangers of nuclear energy, and publicly opposed it – or left it quietly.

On the other side of the coin there is a surge of new ideas about non-nuclear energy solutions. Riding on the crest of the environmental wave a large number of scientists and inventors produce new ideas and develop them. We can already note that the development of non-nuclear energy technologies is proceeding faster than expected, and probably the time scale for the development and use of new solutions to the energy problem should be revised downwards. As the leading nuclear energy advocates aim at 10% nuclear energy in 1990, the political and technical question now is whether the alternative energy "sources" could take care of 10% of the energy in 1990, on condition that the R & D resources and the capital investment which at present are channelled into nuclear energy are switched to these energy sources.

6. The Non-Nuclear Energy Mix

As we all know, the alternative to nuclear energy consists in a mix of a number of other energy "sources". On a short time scale (say by 1990) these are:

a. *Reduction of energy use by a change in life-style* (e.g. smaller cars, lower indoor temperature).

b. *More rational and economic use of energy* (e.g. better house insulation, heat pumps, use of waste heat from power plants for heating, more efficient industrial use).

c. *Coal* (a number of environmental problems should be solved).

d. *Solar energy for heating.*

e. *Oil* (there is enough oil for several decades).

I think the discussion has clearly demonstrated that with a wise and strong energy policy some of these alternatives have a chance of replacing the 10% nuclear energy, and that a mix of them – involving only 2% of each – could very easily do so. Furthermore, the development of *wind generators* seems to proceed well, but it will perhaps not make a large contribution until later. The same holds for *biomass. Solar electric* generators and *hot rock* energy will perhaps require more time before they can share the load, but each of them has such large potentialities that with a sound energy policy there is no risk at all that we shall be energy-starved in the future.

7. Public Acceptability of the New Energy Mix

When from a scientific, technological, and economic point of view a non-nuclear energy mix is clearly motivated we have to discuss to what extent it will be publicly accepted. There are some factors which work against a rapid and general acceptance.

1. A switch in energy policy will necessarily take considerable time because of the very large scale of the enterprise and the long time it takes to plan and build either large energy-producing plants or a large number of small devices.

2. Whereas (b) and (d) seem to be subject to no serious objections (a) and (c) are more controversial. (a) includes changes in habits which many people object to because it is feared that they mean a decrease in the "standard of living", which is not necessarily true. Objections against (c) are quite legitimate, because the use of coal is associated with serious disadvantages. This is to a large extent due to the fact that mining and burning of coal employs essentially 19th century technology which has been modernized only partially. New methods of exploiting the energy of coal are under way, and one may hope that this will lead to a use of coal which is more acceptable from an environmental point of view.

Some of the new technologies are developed with consideration for the environment already at the earliest phase. This gives them an advantage compared with those technologies, such as burning of fossil fuel, which initially were developed with neglect of the environment and now have to be brought up to modern standards.

3. A serious obstacle to an early acceptance of modern energy policy derives no doubt from the nuclear establishment of new technologies for obsolete ones. Those who have invested enthusiasm, work or much capital in a technology which is no longer viable are often facing a difficult and unpleasant situation. It is natural that they react – often in an *emotional* way. It is the duty of scientists, politicians and the general public to find ways of satisfying the legitimate interests and needs of all those for whom the transition to the new energy mix may be a painful process.

This problem can be solved only through a friendly collaboration between the pro-nuclear and the anti-nuclear factions.

IV. THE POSITION OF THE W.C.C.

Public Acceptance of Nuclear Power – Some Ethical Issues

*Prepared by the Energy Advisory Group of the Working Committee on Church and Society, World Council of Churches, Geneva, Switzerland**

1. Introduction

Since the last major International Atomic Energy Agency Conference on "Peaceful Uses of Atomic Energy", nations have been obliged to adjust to significant new factors that have come to dominate the world energy market. At previous meetings, the industrialized nations were assuming a long-term future dependence on the use of nuclear energy for electric power generation. The developing nations were closely monitoring the circumstances governing investment in nuclear power but were for the most part acknowledging that for them the point of entry was some way off. The IAEA itself was acting to provide access to the nuclear option for those nations that were exploring the scale of their future commitment to nuclear energy. There was a certain fluidity in the situation as each nation examined its own position in the general programme of nuclear power development. Public opinion had, for the most part, acknowledged from a distance the availability of nuclear power. But it failed to perceive the implied future scale of dependence on nuclear energy and was apathetic to its social and ethical implications.

Since 1973 there has been a historic shift in this process of gradual appraisal. The rapidly increasing costs and the escalating scale of demand for all forms of primary energy, set against a familiar back-cloth of diminished fossil fuel resources, suddenly brought forward in a dramatic way the threshold of a more substantial world-wide dependence on nuclear energy.

It is not, therefore, surprising that a vibrant debate began to gather momentum outside the nuclear industry with the immediate purpose of raising the level of public awareness of the social, political and technical risks that are inevitably associated with the large-scale and accelerating adoption of nuclear power generation. The nuclear industry has given a mixed response to this debate, to accusations of irresponsibility and to demands for more specific attention to the recognized hazards of the fuel cycle. The World Council of Churches favours the widest possible discussion of these issues. It is most encouraging that the IAEA has been able to admit to this forum contributions that are not committed to the unqualified acceptance of nuclear energy production. It is to be hoped that future discussions will be even broader.

2. The Public Appraisal of Nuclear Energy

For those scientists and engineers who have dedicated their lives to the development of this technology most of the problems posed in the public debate have been part of their concern for a long time. However some of these now take on a fresh importance in the light of public exposure and the growing recognition that particular questions – such as those concerned with the long-lived radioactive wastes – introduced a new time dimension into the concern for environmental protection. Some specific problems have been too long submerged. In any case, a policy of ignoring or treating lightly the volume of public questions and criticism will not work. The nuclear industry cannot afford merely to point to a very creditable safety record in justification of its present action and future plans. There is a collective responsibility on all participants in this conference to address the critical issue in a much more substantive way. While there have been occasional misrepresentations of facts there is now an established body of informed public opinion holding that we cannot proceed to the adoption of a plutonium-based fuel economy without a more fundamental and completely open examination of the risks involved.

In this situation non-governmental bodies such as the World Council of Churches have a responsibility to examine carefully the issues so far identified and to place these in a social and ethical context.[1)]

The W.C.C. involvement in the nuclear debate is only one part of its more general concern for the risks associated with rapid technological change, from the manipulation of genetic material to the prevention of industrial pollution. The W.C.C. wishes to present its general position on nuclear energy as follows:

A. The availability of nuclear energy is a controversial feature of today's world in that it affords the opportunity to provide a large fraction of the world's energy needs, counterbalanced by the exceptional nature of the risks involved, and other problems related to the employment of large-scale, capital-intensive high technology.

B. The maturity of the nuclear energy system is not yet such as to justify its world-wide application; the consequences of large-scale expansion of nuclear production are still relatively poorly understood and require further assessment.

C. The rights of access to nuclear technology should be preserved to the extent that the nuclear 'haves' may not deny the nuclear 'have nots' by any form of exclusive consultation.

D. There should be sufficient discussion of the factors governing access to nuclear technology to bring all nations to a new awareness of its risks and uncertainties as well as its

*) The following members of the Energy Advisory Group prepared this paper: S. Arungu-Olende, John M. Francis, William Nashed, B.C.E. Nwosu, David J. Rose, Roger L. Shinn, Diogo de Gaspar and Paul Abrecht. The Central Committee of the World Council of Churches, meeting in Geneva, August 10-18, 1976, received the Abstract on which this paper is based and authorized the sub-unit on Church and Society to make a presentation on these lines. The Abstract is included at the end of this paper.

1) For example: Report of the 1974 World Conference on Science and Technology for Human Development, *Anticipation* no. 19 (1974) 9, where the W.C.C. first considered the "nuclear power option"; *Facing up to Nuclear Power*, ed. by John Francis and Paul Abrecht (Edinburgh and Philadelphia, 1976), including the report of the Ecumenical Hearing on Nuclear Energy in Sigtuna, Sweden; and "Energy for a Just and Sustainable Society", *Anticipation* no.23 (1976).

opportunities; and the collective responsibility for monitoring and administering safeguards should reside with the IAEA rather than with individual governments.

E. Public confidence in the use of nuclear energy, seriously shaken in recent years, can be revived only by the widest possible public discussion of the technical options and of the value judgements underlying present patterns of energy consumption.

What emerges from these statements is a requirement that decisions governing the future utilization of nuclear energy must now be taken in this larger setting, and that the pattern of nuclear energy supply must be rethought in terms of total world energy needs and the wide disparities in supply that exist at present. In this connection there is need for a new emphasis on the ethical component, in order to perceive the provision of energy resources for all people as an essential part of the struggle for a more just and sustainable society.

Within each country already possessing a basic capability in nuclear technology, certain assumptions have already been made governing the scale, availability and general disposition of their future nuclear development. Such assumptions are now open to challenge. The days of great expectation arising from the birth of nuclear technology have now been foreclosed by the days of decision under uncertainty that presently characterize nuclear power developments in many countries. Surely few are politically naïve enough to suggest that nuclear technology could be abandoned; but a new sense of realism is undoubtedly abroad and challenges to a high level of nuclear dependence must be answered. If public confidence in the future deployment of the technology is further eroded, then re-establishing such confidence will prove undoubtedly to be even harder. A clear definition of future risks and uncertainties would therefore seem essential.

3. The Risks of Nuclear Technology

The W.C.C., in cooperation with a group of nuclear scientists, has studied this matter, and wishes to make clear its own understanding.

The risks are those of inadvertently incurring various social costs, which fall generally into three broad categories: (1) of unintended accidents and hazards associated directly with operation of the technology; (2) of an unquestioning and undesirable dependence upon the technology and the degree of social and economic centralization it incurs; (3) of the misuse of fissionable material for weapons.

Debates like this, far from being new, have appeared with varying seriousness and intensity through all of history.[2] Technological security is a relative matter involving other technologies, other persons, other places, other times. Recalling the lessons of history we recognize that absolute security is a dangerous myth.

It is our understanding that the principal perceived technological risks are these:

(a) ot improper storage of high-level radioactive nuclear wastes;

(b) of catastrophic accidents, principally to nuclear reactors;

(c) of the effect of a multiplicity of low-level releases of radioactivity during normal operation, from various parts of the nuclear cycle;

(d) of possible accidents in fuel reprocessing plants.

2) Agricola in publishing his classic treatise *De re metallica* in 1556 starts his work not with technology but rather with the fundamental questions both of safety and desirability of mining – an issue hotly debated at the time.

Nuclear Waste Disposal

The nuclear waste problem is probably the greatest single cause of public anxiety. It is our understanding that the situation is as follows:

(a) Except for plutonium, the radioactive waste generated per unit of energy produced is about the same for present-day reactors now in service, and for breeder reactors. Thus the nature of the radioactive waste problem is similar for all nuclear reactors.

(b) Regarding plutonium, present-day reactors produce about one-half as much plutonium in their normal course of operation as would a breeder reactor operating on a uranium-plutonium cycle. Some of this plutonium fissions in the reactor during its operation, and the remainder appears in the used fuel. Thus the plutonium question already exists: the main difference is that, with breeder reactors, the plutonium must be recovered from the spent fuel and recycled as new fuel. With present-day reactors the fuel need not necessarily be reprocessed, as long as the reserves of high-grade uranium ore last; but that is only a few decades at most.

(c) Regardless of decisions about civilian nuclear power, a legacy of nuclear wastes exists from weapons programmes in several countries, and its total equals the wastes expected to be produced by all civilian nuclear power plants operating until about AD 2000. Thus at least for some countries, the waste problem is present, real and unavoidable.

It seems to be generally agreed that the critical storage time for the decay products of the civilian reactor programme will depend on the details of chemical separation, but will require safe management for a minimum of about 1,000 years. Beyond that time, the toxicity of the remaining actinides starts to become comparable to that of the uranium ore originally mined.

The need thus arises to do two tasks well: (a) to separate the wastes carefully, recover ^{239}Pu (or ^{233}U), and turn the remainder into an insoluble glassy matrix, without spreading contamination through the plant or surrounding environment; (b) to sequester the residual glassified wastes in appropriate geologic structures.

The public is assured that these activities are technologically feasible. The question is: will the work actually be carried out on the appropriate scale? Past performance has been inadequate, partly to be blamed on the haste of great powers to build nuclear weapons capability. We are assured that the mistakes of the past will not be repeated. It is our judgement that this can be best assured by a policy of open review. However as long as technologically satisfactory solutions to the high level waste disposal problem have not been demonstrated the idea of rapidly expanding nuclear power production is bound to strike much of the public as highly questionable, given the irreversible character of the risk.

Catastrophic Accidents

Many people are concerned about the possibility of catastrophic accidents. Studies in the U.S.[3] of present-day light-water reactors quote the probability of large accidents caused by design, engineering or operating failures (not including hostile acts) as about one chance in a billion per reactor-year of operation, with a loss of several thousand lives. These figures are disputed, but no better ones are yet forthcoming; and there is the further observation that no core melt-down accidents have been reported in about 500 reactor-years of large power plant operation world-wide. Such an event would be the necessary but insufficient precursor to an accident that significantly involves the public.

3) U.S. Nuclear Regulatory Commission Report NUREG-75/014, October 1975 (U.S. National Technical Information Service, Springfield, Va. 26161).

present demonstrable performance requires great dedication to high standards; a few precedents exist, such as for airplane manufacturing, where the record is generally good, but occasionally clouded by conscious problem-avoidance. Predictions of accident patterns show that smaller ones involving little or no public hazard will occur much more frequently than the catastrophic large-loss ones. Thus scrupulous investigation and publicizing of the whole spectrum of small-scale accidents should contribute to avoiding the large ones.

Public concern over major accidents on fast breeder reactors is being widely propagated and the basis for public reassurance is still largely hypothetical. The public naturally believes that since the stored energy in a fast reactor core is greater than in a thermal reactor, then the release of this energy under accident conditions will be proportionately greater. Some of the principal researchers have agreed that they do not have enough knowledge to justify a major commitment to fast reactor technology.[4]

Accidents in Reprocessing Plants

The likelihood and possible severity of accidents in fuel reprocessing plants are hard to judge at present. Experiences in plants processing weapons-type material are largely irrelevant, because they handle uranium or plutonium in its highly reactive pure metallic form, whereas nearly all commercial reactors, planned or in service use oxide fuel. In a civilian nuclear reprocessing plant, the bare metal never appears anywhere in the stream, but only as the relatively (or very) inert nitrate, oxide, etc. Critical amounts of uranium or plutonium salt solutions have accidentally accumulated in processing streams. While the accident hazard here appears small, the probability needs better estimation.

Low-Level Radiation

The routine low-level emissions of nuclear power cause little harm, especially if compared to the environmental and health damage caused by the fossil fuels that it replaces. In fact, the largest hazard would probably arise from uranium mining and milling if the reactors were of the light-water type – about 70 deaths per year. For a breeder, the mining and milling requirements would be 70 times smaller. These numbers stand in striking comparison to recent estimates of death attributable to burning coal in the Eastern United States: for 400,000 MW of coal-electric, the death would be 8000-40.000 per year with no sulphur abatement, and perhaps 1000-4000 per year with full enforcement of the present air quality standards. The statistics on morbidity from this cause are poor, but the effect is undoubtedly large.

Public concern about the risks of nuclear technology has led in many countries to a demand for a moratorium, especially on the reprocessing of spent fuel and on the commercial development of the breeder reactor. Some church groups have adopted this approach. A report by the World Council of Churches' study group has pointed to the possible misuse of the moratorium as a tactic to avoid making a decision or to delay a decision without regard to the consequences.[5] However if a moratorium provides an opportunity for an informed public discussion and the communication of continuing research on technical problems this could be a useful action.

4) F.R. Farmer. "The Safety of a Commercial Fast Reactor", in *Nuclear Reactors: To Breed or not to Breed,* ed. by J. Rotblat (London) 1977, 59-66.

5) "Energy for a Just and Sustainable Society", *Anticipation* no. 23 (1976) 6.

In view of current uncertainties over the maintenance of energy supplies, particularly to large urban communities, the W.C.C. appreciates the necessity of retaining nuclear power as one of several possible options for the future in many countries. This should in no way diminish the search for alternative, long-term, safer forms of energy. The credibility of the nuclear option can be achieved only through the resolution of the major questions inherent in its use. In view of the impending large and irreversible world-wide commitment, these questions must be tackled without further delay.

4. Nuclear Weapons

The possibility of diverting fissionable material for nefarious purposes is important, and has figured significantly in the debate over the advantages and disadvantages of nuclear power.

Our difficulty in discussing the matter stems from the simple fact that the hazard from weapons made from the diversion of materials from the civilian power programme is negligible compared with the hazard from the vast store of nuclear armaments in the military programme. Yet the two hazards are so inextricably linked that they cannot be discussed in proper perspective separately.

At this point we emphasize the finding of the 1975 W.C.C. Hearing on Nuclear Energy concerning Nuclear Energy and Nuclear Weapons:

> *"It is difficult on political and moral grounds to deny countries without nuclear technology the right to obtain it because of a fear that they might use it for the development of nuclear weapons. The proposition that the appropriation of nuclear technology would forever be a limited right, to be doled out by the present nuclear countries according to rules determined by their interest is unacceptable. This would be an intolerable situation for many developing countries seeking to benefit from the peaceful application of nuclear energy and throw off technological domination by the already industrialized countries.*[6]

The 1975 Hearing noted further that the continuing production and possession of nuclear weapons by the major industrial countries was the principal obstacle to nuclear disarmament; and pointed to the serious limitations of the Non-Proliferation Treaty in preventing nuclear arms' proliferation, because "it is based on discrimination in favour of countries already possessing nuclear weapons".[7] Since these statements were made our opinion about the particular vulnerability of the Non-Proliferation Treaty has been reinforced.

Much has been written about the need for the highest possible degree of physical security to prevent the misuse of nuclear materials. Hence, guarding critical nuclear facilities against terrorists would, it is claimed, lead to a virtual police state. Careful calculations based on present experience tend to deny such claims. It is possible to design the system so that such a high degree of physical security is necessary at only a few strategic points – entailing no threat to basic liberties.

5. Access versus Security

Nevertheless two dangers exist: of the misuse of nuclear technology for clandestine weapon-making and the protection by the presently nuclear-armed nations of their proprietary rights.

6) *Facing up to Nuclear Power* (op.cit.), 193.

7) *op.cit.* 193

However in the long run, some of these countries will be on a sufficiently strong industrial and economic footing to support nuclear power installations and be large enough to need the power. There is consequently a growing interest in nuclear energy technology in many developing countries. It may be some time – perhaps 25 to 30 years – before their distribution systems could accommodate the larger nuclear units: but they must start preparing now for the future.[8] This means training of skilled manpower for the maintenance, operation and supervision of nuclear plant installations. Some are seriously considering the feasibility of setting up sub-regional or regional training centres.

The high initial costs of a large nuclear power unit would, it is argued, be met through joint financing along the same lines suggested for the development of large-capacity hydro-electric plants.[9]

The same developing countries have shown great interest in the technical, environmental and social problems associated with the adoption of nuclear technology on a large scale. The candid and honest airing of these problems, the risks involved, the safety limits, resource limits, and waste products and spent fuel management, should go far towards providing a realistic picture for those countries seriously contemplating nuclear energy.

The first of these dangers leads to the nuclear safeguards of the IAEA and other international arrangements, which attempt: (a) to ensure that nuclear materials are used for peaceful purposes only; (b) to deter by early detection the diversion of such materials to illegal purposes; (c) to build up safeguards systems that are as effective as possible within practical national and international limitations. None of these systems is fool-proof. The IAEA's ability to deter diversion can be impeded if a participating government changes its attitude and either withdraws from its treaty obligations or produces critical material in clandestine operations. Furthermore, no safeguards system can be completely satisfactory until the entire nuclear activity in the receiving country is placed under IAEA safeguards. This is not the case in many countries, even though more than 100 nations have subscribed to such safeguards under the Non-Proliferation Treaty.

The countries presently well advanced in nuclear technology are using the Non-Proliferation Treaty to protect their own proprietary interests. This can have two deleterious consequences. First, an additional separation between rich and poor countries can develop. Second, frustration among either non-signers or constrained signers of the Non-Proliferation Treaty can lead to the establishment of new ventures and centres entirely outside the "established" groups. These dangers appear obvious to the public, hence public confidence erodes.

An international decision on the allocation of reprocessing facilities is now urgent and overdue. The present pattern of reprocessing is at an impasse because of the unsolved problems of long-term waste storage. At the same time there is undoubtedly an immediate demand for reprocessing facilities to match reactor programmes even in the major producing countries. Such an important decision cannot be limited to those nations already in consultation over the control of these technologies.

6. Nuclear Energy and a New International Economic Order

Nuclear energy provides the only presently available alternative to fossil fuel and hydro-power for the supply of bulk electric energy, and many countries want its benefits. However, its larger social implications have yet to be adequately identified and explored. Some people are concerned that this complex technology might reinforce the trend towards the centralization and urbanization of society which they would like to reverse. Others fear that it will tend to widen the economic and technological gap between the rich and poor countries. They are also concerned lest the present commerce in nuclear technology undermine the struggle against racial and social injustice. Clearly there is a need to determine how the use of nuclear energy relates to the struggle for a new and more just international economic order.

Thus far most of the debate about nuclear power refers to industrialized countries. The same assumptions do not apply to the developing countries, and there is need to establish how best to accommodate nuclear power programmes within the framework of their development.

A number of factors have precluded the widerspread use of nuclear energy for electricity production in developing countries. Many of the power systems there are of modest proportions and cannot absorb the large nuclear generating units of the order of 600 MW and above.

7. Ethical and Religious Perspectives

Every phase in this analysis has involved an interaction between two kinds of thinking: *one*, highly technical, depending on the knowledge of contemporary scientific experts. The *other* concerns human purposes, values and commitments. These have been the subject of centuries of inquiry by prophets and poets, tragedians and comedians, heroes and saints in all societies. This quest is not the domain of any elite; every human being has a voice and a stake in it.

Although technology exists to serve human needs, it can destroy people and human values, whether by deliberate intent of oppressors or by unintended consequences. Hence the values that guide technological processes require constant public scrutiny and discussion. The question must also be raised whether technological processes are actually serving the ends intended or whether they are proceeding by a momentum of their own that overrides human values.

It would be convenient, if it were possible, to separate neatly goals and values from techniques and means, to assume that societies decide their goals, then enlist scientific technologies to realize them. But in fact technology influences goals. Sometimes it suggests or makes possible new goals not previously envisioned. At other times the technical means used to achieve some goals destroy possibilities of achieving other equally important ones. Any sharp separation of technology from human values greatly oversimplifies the dialectics of the relation between technology and society.

That is why our present contribution to the discussion about the expansion of nuclear power, though based on religious and ethical commitments, has necessarily entered into many technical issues. For the same reason the scientific literature on nuclear energy frequently shows a high sensitivity to the ethical issues connected with the awesome power it makes available.

Thus decisions about large technical issues like nuclear energy are too important to remain confined within the scientific and engineering communities. Yet without the full collaboration of these expert groups there can be no resolution of the questions. The problem is to devise new ways by which technological developments can be examined by some encouraging new examples of creative dialogue between technical experts, governments, and the public as part of a responsible decision-making process.

Scientists themselves are asking about the meaning of their achievements for human life and destiny. Metaphysical

8) Summary Reports, Second African Regional Meeting on Energy, Accra, Ghana, November 8-19, 1976.

9) Appraisal of Current Energy Situation and Future Prospectus in Africa. ECA; E/CN,14/NRSTD/E/2, December 18, 1975.

and spiritual issues hang like a shadow over all the purely practical discussions of nuclear energy.

At the same time religious thinkers are aware that their traditions offer no ready-made answers to the right use of nuclear technology. If they welcome the increasing awareness that science and technology are not the sole ways to truth and wisdom, they know their own limitations, too. A critical attitude toward technological reason must not lead to social confusion, to delight in the irrational, to the veneration of simplistic and utopian solutions to human problems. Moreover no one religious perspective can be accepted today as the spiritual basis of a new world-wide concern for humanity and the right use of science and technology. So the churches and religious leaders are not in a position of moral superiority but share the uncertainty which afflicts our contemporary culture. This however does not diminish but rather heightens the need for a clear sense of moral purpose at the centre of the decision-making process.

In urging continuing conversations on the technical and the ethical-religious aspects of nuclear energy, the W.C.C. Hearing on Nuclear Energy (1975) refused to "put forward categorical recommendations ... in either entirely rejecting, or in whole-heartedly recommending large-scale use of nuclear energy". In submitting this paper we re-emphasize the need for further information, further inquiry, further conversation.

Three Convictions

Nevertheless we do not hesitate to express three convictions:

Pandora's box cannot be closed. We cannot live as though nuclear energy had not been discovered. It is one of the ingredients of our technological age. Campaigns against its development and use in some particular situation must reckon with this fact. We shall find no quick solution to our dilemma, either by abandoning nuclear energy entirely or by devising fool-proof means to control it. The technological system has brought us great benefits but it has also led us into new dangers. Nuclear energy epitomizes this dilemma.

There is need for a continuous conversation among people of diverse faiths and ideologies about the relation of ever-increasing production and consumption of energy, and other economic goods, to the good life and good society. Nuclear energy must not be looked upon as an end in itself, but must serve social justice and quality of life. There is a temptation to seize upon growth in production as a device to evade the demands of social justice. Too often the rich and powerful have sought to answer the rightful demands of the poor not by justice but by promises, sometimes false, of economic and technological progress that would presumably benefit everyone and cost no one anything. While affirming the need of many societies for increased energy, we deny that such energy is either a panacea for contemporary social ills or a substitute for justice. The churches feel a responsibility to take a stand for a new style of life which would emphasize values other than consumption.

The wise use of high technologies, like nuclear fission, depends paradoxically on a new understanding of human limits. The modern spirit has emphasized the energetic technological drive to overcome obstacles, to solve problems and enhance human powers. The record includes glorious achievements. But increasingly voices, often from within the scientific community, are calling people to a new recognition that they are not God, that their power has its limits, that not all problems yield to technological solutions, that humanity must learn to live with nature as well as to harness its resources. A wise humanity will therefore unite aspiration with modesty. Indeed the dilemmas now faced by nuclear scientists may make them especially aware of the validity of the spiritual insight that, in the future as in the past, we must "work out our salvation in fear and trembling".

W.C.C. STATEMENT ON NUCLEAR ENERGY - AUGUST, 1976

The Central Committee having seen the Abstract of the submission on the "Public Acceptance of Nuclear Power" authorizes the sub-unit on Church and Society to make a representation on these lines to the International Conference of the International Atomic Energy Agency, on *Nuclear Power and Its Fuel Cycle,* to be held in Salzburg, May 1977; and in accordance with the recommendations of the Nairobi Assembly encourages the further world-wide ecumenical debate on the technical, moral and spiritual issues posed by the expanding use of nuclear energy.

Abstract of a Submission by the World Council of Churches to the International Atomic Energy Agency (IAEA) Conference on "Nuclear Power and Its Fuel Cycle", Salzburg, May 1977

Through a careful process of investigation and inquiry, the World Council of Churches has become aware of a decline of public confidence in existing social institutions responsible for maintaining and securing the nuclear fuel cycle. In the light of the growing concern, the World Council seeks a direct assurance from the International Atomic Energy Agency (IAEA) and other responsible governmental bodies that new initiatives will be taken to resolve the anxiety and to place the acknowledged risks of an expanding nuclear power industry in a more realistic long-term perspective.

The provision of energy resources for all peoples is an essential part of the struggle for a more just, participatory and sustainable society. In view of current uncertainties over the maintenance of energy supplies, particularly to large urban communities, the W.C.C. appreciates the necessity of retaining nuclear power as one of several possible options for the future in many countries. This should in no way diminish the search for alternative safer forms of energy. The credibility of the nuclear option can be achieved only through the resolution of the major questions that are inherent in the use of nuclear technology. These questions must be tackled without further delay and certainly before a large and irreversible world-wide commitment is made.

1. *The need for an open public debate.* Without full public consultation on the social and ethical implications of long-term energy choices, decisions will be taken largely in terms of commercial and consequently short-term economic interest. Moreover, at present, the public debate is confused. Advocates of nuclear energy plead the achievements of unproven technology, minimizing the unsolved problems, while critics ignore the societal costs of other major energy options, and demand an unrealistic absolute perfection in the design and construction of nuclear power systems. The churches seek to encourage an informed public examination of these issues.

2. *Facing the long-term risks of adopting nuclear technology.* The W.C.C. stresses the necessity of resolving the problems of secure waste disposal and those posed by the drift into a dependency on the plutonium fuel economy. While much of the present debate and current analysis focusses on the performance of light-water reactors, the predominant issue concerns the operation and safe management of breeder reactors without which nuclear fission has no long-term existence.

3. *Access versus security.* Concern for the security of sensitive nuclear technologies has produced the secretive nuclear club. A just global society implies not merely equal opportunity to aspire and to achieve, but affirmative action to redress imbalances. This is incompatible with the pseudo-secrecy and patronage practiced by developed nuclear countries. The W.C.C. is concerned how the "access" versus "security" issue is to be resolved.

4. *Military implications.* The development of nuclear energy for civilian purposes is linked with the development of nuclear weapons. The nature of this "coupling" and the principles guiding those who try to contain the spread of nuclear weapons must be directly related to the anticipated future scale and technologies of nuclear energy production.

5. *Social implications of nuclear energy.* Nuclear energy provides the only presently available alternative to fossil fuels and hydro-power for the supply of bulk electric energy. However this sophisticated technology seems likely to reinforce the trend to centralization and urbanization of society which many are trying to reverse. Moreover, the sale of nuclear technology to regimes with repressive social and racial policies has further heightened the fear that nuclear energy will increase injustice. At the same time all countries want the benefits of nuclear energy. The social implications of what is done need to be identified and explored.

6. *Ethical and religious issues.* The validity of underlying presuppositions of faith and values that appear in the debate over the future role of nuclear energy needs to be acknowledged and examined. The paradox of nuclear energy in offering the prospect of immense potential and many incalculable risks remains totally unresolved. The decisions are too important to remain confined within the technical arena of the nuclear scientific and engineering communities. However, without the full collaboration of these expert groups there can be no resolution of the questions already listed, and in each national situation, the World Council of Churches appeals to this body of expertise to provide a more considered response to these questions.

V. PRESENTATION OF THE W.C.C. POSITION AT SALZBURG

JOHN FRANCIS

In following the two distinguished speakers you have heard already this morning I want to interpret for you the perspective of the World Council of Churches, whose paper is available to you. The World Council is an association of 289 Christian churches numbering some 450 million members of the Protestant, Anglican and Orthodox communions. Let me say also that the World Council is far from making some final judgement about the rightness or wrongness of nuclear energy. Many of our member churches around the world are only beginning to discover the problems associated with the further development of nuclear power systems. Our concern is to encourage them to take the issues seriously, to avoid premature judgements and to see the problem in its world perspective. The churches share the temptation to reach a verdict quickly, influenced as they are by a great variety of pressure groups and so-called experts on one side or the other.

Pronouncements of this type usually over-simplify the point on which the churches *might* have something to say: the ethical or theological dimension. It is easy to assume that while the technical issues of nuclear energy are difficult, the ethical issues at least hang on straightforward choices – 'yes' or 'no'. But things aren't so simple. As we make clear in our paper, ethical issues are connected to technical ones; therefore the ethical issues cannot be resolved by theologians or others working in isolation from the technical complexities. Our ecumenical approach must involve dialogue between scientists of differing views and theologians and must also get close to people directly involved with particular problems. As we see it, the debate will and must go on. The only question is whether it will go on creatively, openly and imaginatively or whether it will be polarized and sterile.

The Validity of the Public Questions about Nuclear Energy

In our paper, we hold that it is right for the public to challenge the way nuclear power is developed. The harnessing of nuclear energy is not an unnatural phenomenon, but rather an exceptional phenomenon, capable of setting a

unique challenge to the ingenuity and moral courage of people everywhere.

We all recognize major unknowns connected with the management and operation of the nuclear fuel cycle. It is therefore essential to respond to those voices in so many different places that seek clearer answers to a growing list of valid questions. We know that many of the questions must remain unanswered for perhaps a decade or two longer. We must not promise more than we know we can deliver. It is all too easy to be defensive, to rest on a good operational record or to insist that the solution – in a technical sense – lies around the corner. In many countries the great mass of the population picks up the bill for nuclear power development; the time has arrived for a proper level of public accountability, not only in financial terms, but more especially in terms of the issues that people *feel* to be important. What is desperately needed is more careful thought and a great deal more human sympathy over the broader issues of nuclear energy. Without this there can be no real prospect of the public acceptance of nuclear energy.

When attempts are made to exchange information or to define public anxieties over plans for nuclear projects, there is frequently a complete failure to understand the objector's standpoint. Here is a tangible example of what we mean. Earlier this year the Nuclear Inspectorate in the U.K. replied in public to some questions on nuclear safety. In response to a question on risks associated with fast reactor siting, the answer that appeared in a leading newspaper was as follows:

> *'The worst credible accident involving a fast breeder reactor in an urban site would result in several thousand deaths within a few weeks of the accident in an area extending about 10 kms downwind of the reactor".... There would also be some increase in the risk of cancer in those exposed to somewhat smaller doses than the lethal level. The exposed zone would extend "for a few hundred kilometres downwind". These are the first official estimates to be published by the inspectorate, which goes on to say that it can nevertheless see no reason why a commercial fast breeder reactor cannot be made "safe enough to be licensed".*

I think that most people would feel far from reassured by such a statement; but statements of this character – made in good faith – point to very real difficulties of communication with the public at large. The World Council of Churches is only too well aware of the scholarly efforts that are being made to understand risk as a social phenomenon – for example the valuable work that is being done on behalf of the Agency by Harry Otway and his team, – but the question that remains is whether far too great a reliance is placed on the academic approach.

The manipulation of statistical information is a skilled craft but the numbers can have very little significance if they fail to reflect the more immediate concerns of a community which sees its way of life threatened by the prospect of a nuclear energy project on its doorstep. There is an emotional and psychological barrier to be overcome. It is not simply the sterilization of land but the much more enduring commitment to contain the worst aspects of the nuclear dustbin that alarms the public at large. While it may to some represent the ultimate conquest of mankind over nature, to others it is little more than a cruel deception which will inevitably visit the inadequacies of our present technology on those that come after us. The sense of alarm is real enough and the nuclear community should not belittle those who succeed in reminding us of our longer terms responsibilities.

The Public Evaluation of the Risks from Nuclear Power

If the right of the public to challenge nuclear policies and programmes must be stressed, it must also be said that the public debate often suffers from a confusion over the different levels of risk. Misrepresentation of facts can become a form of cruel amusement. For example, it is often argued that the practical containment of risks is certain to demand ultra-high security in a world teetering towards instability. To respond that this will only be attainable under conditions of much greater social and political stability is a logical paradox – but it does not answer the question and the public has a right to insist that more reasonable assumptions are made in the advice offered to politicians. We have in our paper challenged the view that this advice must necessarily lead to a police state. In our highly vulnerable world, we are already accustomed, by necessity, to a degree of security and surveillance that some find excessive; it should come as no surprise therefore that this must be increasingly part of the cost of handling sensitive nuclear technologies.

Nor can we readily answer the fears of those aroused by the threat of nuclear installations to local interests particularly where there are uncertainties over public liability for accidents. The social costs of the nuclear presence are not substantially different from that of any large-scale industrial investment. It is inevitable that local communities will now demand to be part of the decision-making process at many different levels; certainly the advocates of nuclear power will have a harder time than previous environmental intruders to win the confidence of local groups driven by their own natural fears and anxieties. There have been confrontations already in France, Germany, Switzerland and in Japan that clearly indicate the commitment of local action groups against nuclear energy; in the United States the electorate has been consulted through the referendum process in some States. In other countries, governments have changed under circumstances in which nuclear power was a prominent electoral issue.

With respect to all such issues, the World Council of Churches stands on certain basic assumptions which must influence its position both on the resolvable and the irresolvable issues arising in any particular nation or locality. Our paper shows that we have reached a provisional consensus along the following lines:

(1) Nuclear energy offers the potential of providing a large part of the world's energy needs, counter-balanced by some exceptional risks. It would be politically naïve to think that nuclear energy will or can be abandoned.

(2) The maturity of the nuclear energy system is not yet such as to justify large-scale, or unlimited application; the consequences of further large-scale dependence need to be further assessed.

(3) The right of access to nuclear technology must be recognized; the nuclear "haves" should not deny the nuclear "have nots" by any form of exclusive consultation.

(4) The issues of access and security involve the collective responsibility of all nations which needs to be assessed anew and administered through the IAEA, with more clearly defined functional objectives geared to the anticipated scale of the task.

The main risks of nuclear power are discussed in the text of our paper and I shall only identify two which loom large in the public debate.

Nuclear Waste Disposal

The public is assured that methods of dealing with the long-term waste problem are generally feasible. The question is: Will the work actually be carried out on the appropriate scale? Past performance has been inadequate, partly to be blamed on the haste of great powers to build nuclear weapons capability. We are told time and time again that the

mistakes of the past will not be repeated. It is our judgement that this can only be assured by a policy of open review. However as long as satisfactory technical solutions to the high level waste disposal problem have not been put into practice, the idea of rapidly expanding nuclear power production is bound to strike much of the public as highly questionable, given the irreversible nature of the risk.

Catastrophic Accidents

Many people are concerned about the possibility of catastrophic accidents. Studies of present-day reactors quote the probability of large accidents caused by design, engineering or operating failures (not including hostile acts) as about one chance in a billion per reactor-year of operation, with a loss of several thousand lives. These figures are disputed, but no better ones are yet forthcoming; one of the problems of public acceptability is that most people are not familiar with probability theory. If it is stated that nuclear power is as safe as possible, people can apparently come to terms with the risk. On the other hand, the same level of risk described as a one-in-a-billion chance will make people uneasy; this is more than a difficulty of communication.

Public concern over major accidents on fast breeder reactors is already being widely propagated and the basis for public reassurance is still largely hypothetical. The public naturally believes that since the stored energy in a fast reactor core is greater than in a thermal reactor, the release of this energy under accident conditions will be proportionately greater. But should fast reactor risks be singled out for special attention in the debate about public acceptability? We suspect that if the earlier generations of civil nuclear reactors had been subjected to the same level of public scrutiny, nuclear energy might have come more slowly than it has in fact.

Public concern over the risks of nuclear technology has led in some countries to a demand for a moratorium, especially on the reprocessing of spent fuel and on the commercial development of the breeder reactor. Activists including some church groups have favoured this approach. They link this with the search for alternative, long-term, safer forms of energy. A recent national opinion poll in Britain posed the question "Should we keep our options open, do everything we can to save 'conventional' fuels and keep looking for other sources of energy apart from nuclear power?" Overall, a clear majority of people (61%) chose this alternative to a straight go-ahead on nuclear power. However, it is most significant that when people were asked whose opinion they would most trust on the safety of nuclear power stations, a remarkable 69% of those polled chose scientists. In contrast, the press and television stood very low in public esteem on this issue.

Access versus Security

On the question of the right of access to nuclear technology the World Council of Churches, while recognizing the dangers of nuclear proliferation, has made its position quite clear:

> *"It is difficult on political and moral grounds to deny countries without nuclear technology the right to obtain it because of a fear that they might use it for the development of nuclear weapons. The proposition that the appropriation of nuclear technology would forever be a limited right, to be doled out by the present nuclear countries according to rules determined by their interest is unacceptable. This would be an intolerable situation for many developing countries seeking to benefit from the peaceful application of nuclear energy and to throw off technological domination by the already industrialized countries."*

It does seem that the countries presently well-advanced in this field are using the Non-Proliferation Treaty to protect their own proprietary interests. This can have two deleterious consequences. First, an additional separation between rich and poor countries can develop. Second, frustration among either non-signers or constrained signers of the Non-Proliferation Treaty can lead to new strategic problems entirely outside the "established" pattern. These dangers appear obvious to the public, hence public confidence erodes.

The Need for an Ethical and Religious Perspective

Much of the public debate about nuclear power is troubled. Obviously there are disagreements about technical questions. At the same time there is no clear agreement on the values and commitments which might guide us in rightly and truly evaluating the use of nuclear power. We do not believe that our religious traditions have ready-made answers; but the human use of nuclear technology cannot be taken for granted. It is gratifying that the scientific literature on nuclear energy frequently shows a high sensitivity to the ethical issues. Scientists themselves are asking about the meaning of their achievements for human life and destiny. As a consequence, metaphysical and spiritual issues hang like a shadow over all the purely practical discussions of nuclear energy.

We have in our own studies reached three major convictions:

(1) Pandora's box cannot be closed. We cannot live as though nuclear energy had not been discovered. Campaigns against the development and use in some particular situation must reckon with this fact. We shall find no quick solution to our dilemma, either by abandoning nuclear energy entirely or by devising fool-proof means to control it. Our technological systems have brought us great benefits but they have also led us into new dangers. Nuclear energy epitomizes this dilemma.

(2) There is need for a vigorous exchange of views among people of diverse faiths and ideologies about the relation of ever-increasing production and consumption of energy, and other economic goods, to the good life and the good society. Nuclear energy must not be looked upon as an end in itself, but must serve social justice and quality of life. While affirming the need of many societies for increased energy production, we deny that such energy is either a panacea for contemporary social ills or a substitute for justice. The churches feel a responsibility to take a stand for a new style of life which would emphasize values other than consumption.

(3) The wise use of nuclear technology depends paradoxically on a new understanding of human limits. The modern spirit has emphasized the energetic technical drive to overcome obstacles, to solve problems and to enhance human powers. The record includes glorious achievements. But increasingly voices, often from within the scientific community, are calling people to a new recognition that they are not God, that their power has its limits, that not all problems yield to technological solutions, that humanity must learn to live with nature as well as to harness its resources.

These are the views which the World Council of Churches wishes to bring to the attention of this Conference. It is a principal function of the Conference to live up to the public trust with which nuclear scientists and engineers have so far been endowed.

VI. NUCLEAR ENERGY AT THE TURNING POINT

ALVIN M. WEINBERG

Six years ago at the fourth International Conference on the Peaceful Uses of Atomic Energy I presented a paper with Dr. Philip Hammond that opened with the following words:

"We in the peaceful nuclear energy community have been comfortable in the belief that what we have wrought over the past 30 years has been an unmitigated blessing for mankind. It comes as a disconcerting shock therefore to find that, just when nuclear energy has achieved such great success, our effort is being challenged on the most fundamental grounds. Where we claim nuclear energy is clean, safe, and necessary, critical voices, particularly in the United States claim it is unclean, unsafe, unnecessary.

"We have always conceded that, in opting for nuclear energy, mankind is assuming a certain risk. Nuclear energy *is* potentially more dangerous than other forms of energy. It is only by scrupulous attention to detail, and exertion of great care, that we can expect to maintain the safety of nuclear power. So far we have been highly successful.

"Yet there is a much more difficult and profound issue. We are still at the very beginning of the nuclear age. As we think about the possibilities and dangers of nuclear power, we tend inevitably to think of nuclear power as an isolated, smallish thing. But in the very long run, nuclear energy will almost surely be the dominant energy source. At that time, will we have to confront entirely new questions of environmental impact, questions that could conceivably compromise the whole path we are now taking? "

These words, uttered half-a-dozen years ago, have become distressingly relevant today. Our enterprise is not merely on the defensive: in some quarters it is in danger of extinction. In particular, the moratorium on fuel reprocessing in the United States inevitably questions the basic course most of the nuclear enterprise has been following for the past generation.

It will be my purpose first to re-examine why our enterprise is in retreat in so many places; then to ask, "Can we do without uranium? ", and finally to propose paths and actions that I believe we shall have to take to achieve an acceptable nuclear future.

Why is Nuclear Energy in Retreat?

We are beleaguered for many reasons. First, many of us were too euphoric in our expectations of nuclear energy. Many are the times I would like to unsay the words I expressed at the tenth anniversary of IAEA in Vienna a decade ago. At that time, with Oyster Creek being contracted at a little over $100/kW, it seemed plausible to expect nuclear energy to be extremely cheap, as well as inexhaustible. Our dreams of nuclear-powered agro-industrial complexes seemed like legitimate extrapolations from what we thought was demonstrated technology. That the technology turned out to be much more expensive for reasons that few could foresee, or that other sources of energy have also become very expensive, is beside the point: disillusionment with our predictions made it difficult for the nuclear community to retain the confidence of some of the public.

Second, despite the escalation of cost, nuclear energy in the past half-dozen years has become immensely important – more important, say, than the three wise men of Euratom predicted in the middle 1950's. Their goal of 15,000 megawatts in Western Europe by the late 1960's has been long passed. But in becoming important, nuclear energy has intruded on the public consciousness. Basic concerns about *massive* radioactivity, which after all is a new thing on earth, have become widespread simply because nuclear energy itself is widespread. Moreover, I do not believe we in the community have really anticipated the systems problems of a fully deployed nuclear economy. We did not take fully seriously the possibility that nuclear energy would be as successful as it has become. Thus we did not clearly plan how to expand uranium supply or enrichment capacity or all of the details of the waste management system to meet the demands of a totally deployed nuclear energy enterprise. We expected these to happen rather automatically in response to market forces, or as in the case of waste disposal, to be deferrable.

Third, we are entering the maturity of nuclear energy at the same time the world has discovered the environment. It may have been naïve of us to believe that because a *properly* operating nuclear system is far less polluting than is a coal-burning power plant that we could permanently win over the environmental movement to the banner of nuclear energy. But with our present means of rapid communication, doubts and concerns – of which some are legitimate, some are not – easily escalate. Though nuclear moratoria, legislation and initiatives in the U.S. have all been defeated by approximately a 2 to 1 margin, a consensus with respect to the underlying desirability of nuclear energy in many countries no longer exists. In the absence of consensus the nuclear regulatory process is subverted: licensing a reactor becomes a battle in what one U.S. Nuclear Regulatory commissioner has called a "religious war".

All of this is played against the threat of proliferation – and this concern which to some is viewed as the overriding objection to nuclear energy has in the past year affected the course of nuclear development more drastically than any other single factor. The recent decisions in the U.S. both with respect to recycle and the Clinch River Breeder were made largely because of concern over proliferation. Proliferation has become a sort of ultimate Sword of Damocles that hangs over nuclear energy.

Can We Do Without Uranium?

Faced with these and other objections to the very validity of our enterprise, I think it is necessary for us to confront once again the original question – Can we do without uranium? The answer must of course be yes:

civilization would not perish had fission not been discovered. After all, there was nothing fore-ordained about the discovery of fission in 1938 or about η, the number of neutrons produced per neutron absorbed, being greater than unity. Had η been less than 1, a chain reaction would have been impossible; and had η been less than 2, a breeder would be impossible. That God happened to legislate η (^{239}Pu) = 2.8 for fast neutrons, and that man was lucky enough in 1938 to discover fission, which in a way is an oddity, rather than a central thread in nuclear science, must be regarded as a bit accidental. And before 1938, those who speculated on man's future were prepared to contemplate a world that knew no nuclear energy: when the fossil fuels ran out, it was generally expected that we would turn to the sun – either directly or perhaps in the form of biomass, or wind (Palmer Putnam's big windmill at Grandpa's Knob in Vermont was completed in the early 1940's) or ocean thermal gradients (Claude's experiments in the 1920's and 1930's); and some geothermal energy. So a fission-free world was the only world until 1938, and somehow our society seemed prepared to get along.

And in the very short run, for countries well-endowed with coal, fission can be replaced by coal. At the Institute for Energy Analysis we have examined the consequences of a nuclear moratorium in the United States beginning in 1985 and lasting until 2010. Our main conclusion, which followed largely from our projection of a relatively low rate of energy growth in the U.S. was that in principle we could largely substitute coal for uranium beyond what we now use over this period – but that the pressure on coal would be very heavy: we would have to face the possibility of digging some 5×10^9 tons of coal per year about 8 times our present coal production. But this analysis is of little relevance for the large parts of the world that possess no coal or oil – for them an alternative to fossil fuel is a necessity even in the relatively short run.

The dreamers of the pre-fission era, particularly H.G. Wells, were aware that an inexhaustible, cheap source of energy was eventually necessary if not for the survival of the race, then to set the world free from Malthusian Catastrophe. And Wells' simple message, later reiterated by Sir Charles Darwin in his *The Next Million Years* – that eventually man's fate depends on the energy at his disposal – remains as true today as when he first delivered it some 60 years ago.

Let us then examine what a world without uranium might look like; but more than that a world without fossil fuel as well. We must contemplate this latter eventuality, bizarre as it seems, on two accounts: first, our fossil reserve though very large, is finite; but second, and possibly more important, we may have to limit our burning of fossil fuel because of a possible CO_2 catastrophe.

The atmosphere contains about 700×10^9 tons of carbon in the form of CO_2. The concentration of CO_2 in the atmosphere has been increasing at the rate of about 0.8 ppm each year; it has risen from about 315 parts per million (ppm) to 330 parts per million in the 19 years since Keeling began to monitor CO_2 in 1958. Though there is still some doubt on this score, the evidence strongly suggests that the increased CO_2 comes from the burning of fossil fuel rather than from clearing of forests. About one-half of the CO_2 injected into the atmosphere from burnt fuel remains there. Thus if the estimated total world coal resource of 10×10^{12} tons eventually is burned, and one-half remains in the atmosphere, the CO_2 concentration might increase about eightfold. If only the reserve base is burned (the reserve base being defined as the amount recoverable at about present cost with present-day techniques), the CO_2 concentration would more than double.

When this might happen no one knows. Many guesses as to the world's ultimate energy demand have been made in recent years; one of the best known is that of F. Niehaus, who projects by 2050 an asymptotic world producing energy at a rate of 9 times the present – about 2000 quads (1 quad = 10^{15} kilojoules) per year compared to the present 230 quads per year. R. Rotty at the Institute for Energy Analysis estimated the world's energy demand separately for developed and developing countries. He arrives at a total demand of 1,200 quads by the year 2025; the bulk of the expansion comes from the less developed countries since, Rotty argues, these countries use so little energy per capita now, they are likely to increase both their per capita use of energy and their total population relatively faster than the developed countries. Rotty's projections are in fair agreement with those presented at the November 1976 joint meeting of the American and European Nuclear Societies by André Giraud of France. Though Rotty's scenario still allocates but 50×10^6 kilojoules/person/year in the Third World – only 1/5 that used in the developed countries, the total relative contribution to energy demand from the underdeveloped world increases from less than 20% to more than half by 2025. Before accepting this scenario I must concede that some economists, naturally Prof. Hautaker, claim that price alone will prevent the world's energy demand exceeding 500 quads by 2025. Nevertheless I believe it is prudent to assume that the Third World will not forever be content with a per capita energy expenditure 1/10th or 1/20th that of the developed world.

Let us then examine the consequences of Niehaus' scenario – 2000 quads by 2050. If the bulk of this energy is supplied by fossil fuel, the CO_2 concentration may double by about 2025. Unfortunately we cannot say with certainty what the effect on climate of this increase will be: H. Flohn of Bonn suggests a 300 – 500 kilometer shift poleward of the climatic zones. Manabe and Weatherald, using a global circulation model, predict that a doubled CO_2 concentration will increase the overall average global temperature by 1 to 3°C, the pole temperature by 8°C. Such a strong shift would almost surely change the world's climatic zones in an unprecedented way, with economic consequences and effects on agriculture that no one can foresee. Let me hasten to point out that Manabe and Weatherald's model is incomplete – in particular it does not include cloud feedback, nor does it adequately treat the sea-air interface. And indeed, the effect of CO_2 may be in a basic sense unpredictable – we may have to allow the climate itself to tell us how it will react to a doubled CO_2 concentration. But the point is that, far-fetched as it may seem to some, CO_2 may be another Sword of Damocles that hangs over our industrial society, and that may end the fossil fuel era much sooner than would be expected simply from depletion of coal. Above all it injects a somber note of uncertainty into our energy future, one that we ignore at our peril.

It is perhaps unbecoming for a committed nuclear proponent to make so much of the one problem posed by the expanded use of fossil fuel that may, more than any other, demand a rapid conversion of the world's energy system to non-fossil sources. Yet I believe it is time for our political people to recognize this possibility. I do not believe it is premature for the appropriate United Nations Agency to form a group of international experts who can better define the CO_2 problem, assess global and national consequences, and propose credible responses.

Asymptotic Energy Scenarios

Let us then consider how man might provide 2000 quads of energy annually after he has used his fossil fuel, or has decided to husband it for petrochemicals, or must proscribe its use because of the CO_2 catastrophe. I shall

examine two possibilities: one based primarily on the sun and other renewable resources; and a second based upon nuclear energy. To do this properly we should analyze each end use and estimate how much energy is used as low temperature heat, high temperature heat, electricity, and mechanical work (largely transport). This I have not done and my speculations can be faulted in this respect. Instead I have simply assumed that 25% or 500 quads goes for space and water heating, and that at least 50% or 1000 quads (100×10^{12} kWh) goes through electricity. The remaining 500 quads – largely comprising transport – I shall assume are provided either by electricity, or by some renewable source that can substitute for petrol. This breakdown is close to the one many analysts project for the United States by the turn of the century.

The Sun and Other Renewable Sources

How could we meet this budget with renewable sources? Aside from the sun, geothermal energy seems to be the largest such source. Yet the steady state geothermal gradient on land is only 200 quads/year, and most of this is unusable for generating electricity – we might count on perhaps 10 quads of heat, 2×10^{12} kWh of electricity. Hydro, wind, waves and tides can hardly add more than 12×10^{12} kWh. Thus, at the energy demand we project, these sources can hardly make a dent on the requirement placed on the sun.

What then would be involved in deriving from the sun 500 quads for space and water heating, 500 quads for transport and some high temperature heat, and 1000 quads (100×10^{12} kWh) as electricity? The 500 quads for space and water heating seems easiest: I shall assume all of this can be provided directly by the sun, though this certainly will require many changes in the way we build our houses.

The 500 quads for transport and some high temperature heat we shall provide with biomass since the use of biomass does not add to the net CO_2 burden in the atmosphere. Now if we assume a photosynthetic efficiency of 0.7% – which is 5 times the global average of 0.13%, then to get 500 quads from biomass would require about 13×10^6 km^2 of land – about 10% of the earth's land mass. When one considers that in this asymptotic state much land will be needed for growing food, 1/10 of the world's land area devoted to growing biomass for energy seems excessive. Conceivably this could be reduced if practical photosynthetic yields say 5 times larger could be achieved. But this is surely an advance that we have no right to assume will come to pass. One can hardly escape the impression that biomass on so large scale is barely practical.

I would say the same for solar electricity *if it is the primary source of energy.* It is not that the required land area is impossibly large: At 18% conversion efficiency, with either power towers or photovoltaics, we can get 300 kWh/m^2/year from the sun. Thus to supply 100×10^{12} kWh annually would require 3×10^5 km^2, which is very large but not impossible. (Note that electricity can be produced directly from the sun with photovoltaics some 50 times as efficiently as it can be produced from biomass burned in a power plant.)

The main problem of course is storage. Ordinarily we think of a solar electric system as a supplement to a firmly based fossil or nuclear fuelled electrical system. In that event the system does not require storage for more than, say, about 12 hours. But if the solar electric system truly stands alone, then it must store enough electricity to tide one over protracted periods of cloudiness – say 6 to 12 days per year. Storage of electricity is expensive: say $ 40/kWh. And if we require 6-days storage, then the capital cost of a stand-alone solar electric system would be 100 ¢ per annual kWh – some 3 times as much as the capital cost of an incremental system that required no storage. This is to be compared with a fossil or nuclear plant which at $ 1,500/kW would cost about 25 ¢/annual kWh. Even taking into account the cost of the fuel cycle – say 5 mills/kWh – it seems that electricity from a stand alone solar system will be several times – perhaps as much as 4 times as expensive as electricity from nuclear sources.

Am I being fair to the sun in making this judgement? Obviously improvements will be forthcoming – for example co-generation, or better collectors, possibly even the ocean thermal gradient system which I believe deserves much more serious attention than it has received thus far. But these are hopes, not realities. Our general experience has been that untried energy systems cost more, not less, in practice than in therory. I conclude that an all-solar world would be possible, but could not provide as much as 2000 quads or would require the world to pay much more for a unit of electricity than it now pays or both.

An Ultimate Future Based on Breeders

What would be involved in meeting our projected energy demand with breeders? Rather than assume the entire 2000 quads is provided by nuclear sources, I shall again assume that space and water heating, amounting to 500 quads, is provided by the sun. There then remains some 1500 quads (less the small amount provided by geothermal and other renewable resources) to take care of industrial heat, transport, and electricity. For simplicity we shall assume that all these demands can be provided electrically: industrial heat with high temperature heat pumps, transport by batteries or other electric drive.

A 1000 MW reactor converts heat into electricity at a rate of .06 quads per year. Thus an asymptotic energy system generating 1500 quads/year – which is converted into 150×10^{12} kWh – would require 25,000 1,000 MW reactors – or, since the unit size historically has been maintained as a fixed fraction of the total electrical system, say 5000 reactors each of 5000 MW. Is such an energy system based on breeders plausible?

The readily calculable constraints such as uranium requirement, global heat load, and land committed to waste disposal do not appear to be limiting. The global heat load, about 60 TW is only 1/10th the equivalent heat load caused by a doubling of CO_2 concentration. The system would require about 30,000 tons of U/year – which to be sure would mean burning the residual uranium and thorium in the rocks or extracting uranium from the sea. And the burial of high level wastes, at 0.6 hectares/reactor/year, would preempt 25 km^2 each year – after 1000 years 25,000 km^2 will have been used but by that time the radioactivity would have decayed sufficiently to permit layering of new wastes above the old. But altogether these do not seem to me to pose insuperable difficulties.

It is the malfunctioning of the system particularly the possibility of accident and traffic in plutonium that gives one pause. We do not have estimates of uncontained melt-downs in breeders comparable to Rasmussen's estimate of 0.5×10^{-4}/year for an uncontained melt-down in an LWR. If we assume the same probability for the breeders in our asymptotic system, then for 5000 reactors the a priori expected uncontained melt-down rate would be 0.25/year – i.e. one such accident every four years.

To be sure, the majority of these melt-downs would cause little off-site damage. Nevertheless it remains to be seen whether a reactor accident every 4 years will be tolerable. My own instinct is that in the present climate the answer would be no; but in the future I believe it is fair to assume first that the accident probability will be reduced much below Rasmussen's 5×10^{-4}, and second, that the public will eventually accept radiation as a part of life's

hazards rather than being viewed as something mysterious and special.

The total plutonium in the system amounts to 125,000 tons and at a burn-up of 100,000 MWD/ton, about 50,000 tons of Pu is reprocessed each year. This amounts to about 100 tons per day that must be accounted for – a staggering amount.

These oversimplified estimates reinforce the view Dr. Hammond and I expressed 6 years ago – that the price nuclear energy demands if it indeed becomes the dominant energy system, may be an attention to detail, and a dedication of the nuclear cadre that goes much beyond what most other technologies demand. I realize that many in our nuclear community would deny these assertions: but I would insist that we are unaccustomed, perhaps unwilling, to project our technology as far as I have – unwilling in a sense, to face up to the consequences of complete success. When one does, one cannot avoid recognition of the social problems posed by our technology.

Can We Construct an Acceptable Nuclear Future ?

I put the previous scenarios forward with much diffidence, especially since events proved me so poor a prophet when in Vienna 10 years ago I estimated nuclear energy would be 10 times less expensive that it has turned out to be. And indeed, there are many possibilities that could change things drastically: the world may never require 2000 quads either because population levels off or because the disparity in energy demand between rich and poor will somehow be maintained; or fusion may work and be cheaper than breeders, or possibly one of the electrical breeder schemes will be feasible; or solar energy may eventually turn out to be much cheaper than any of us can here imagine, but using means and mechanisms that none can here imagine either. But this much seems clear: that if the world foreswears nuclear energy, from what we now know of solar energy the world would have to adjust permanently either to much more expensive energy than we now enjoy, or *much* less energy then the developed countries use, or both. In this sense we can hardly do without uranium.

And, of course, the future energy system is unlikely to be based exclusively on nuclear reactors or exclusively on renewable resources: it will be a mixture. Actually in my nuclear scenario I still assign space and water heating, amounting to 500 quads to the sun; I would guess that biomass will be used much more widely and wind and geothermal will be exploited to the full, and possibly OTEC. But these will not change the problem qualitatively. Unless fusion works we shall still have to contemplate a world that ultimately depends on many thousands of nuclear reactors. And even in a world using only 500 quads with 375 quads coming from nuclear reactors, each one now being only 1300 MWe size, we would still have some 5000 breeders.

Such a world is not a simple one. The world-wide melt-down rate of 0.25 per year may well be unacceptable; and if one is worried about proliferation now, how can we seriously contemplate a world in which as much as 100 tons of plutonium may be reprocessed *every day?* It appears to me then that the future of our enterprise depends somehow on our devising a nuclear system that confronts these contingencies – melt-down and proliferation – fully and unflinchingly and with the realization that the system we devise must last for a very long time. To do this we must try to visualize the system's difficulties, possibly even exaggerating them by presenting scenarios which some may consider impossibly expansive. Can we then conceive of fixes, both technical and institutional, that would allow us to have nuclear energy under conditions that the future will find acceptable? What might be some of the characteristics of such fixes?

As for reducing the a priori probability of an uncontained melt-down, I believe this we will gradually achieve. The Rasmussen study identified specific weaknesses that contribute most significantly to the 5×10^{-5}/year uncontained melt-down rate. As Smidt and Salvatori pointed out at the Washington ANS-ENS meeting, failure of two check valves following a *small* not a large pipe rupture contributed most to this probability. Having pinpointed the weakness, it has been possible to correct it. And I believe it is quite likely that the Rasmussen probability can and will be indeed well below 5×10^{-5}/year. But having done all we can technically, we must still rationalize the institutional structures of nuclear energy for the long term.

A fully developed nuclear system will almost surely have to be one which commits only certain pieces of land to radioactive operations. These pieces of land will have to be dedicated into perpetuity in much the same way that certain lands in the U.S. are committed into perpetuity for use as national parks. These sites would have to be chosen to accommodate the characteristics of nuclear reactors rather than of the existing electrical grid. Moreover, I continue to believe that some degree of collocation of reactor and recycling facilities is desirable. I simply cannot imagine a nuclear energy system as large as the one I project or for that matter even 1/5 as large is credible unless traffic in fissile material and radioactivity is kept to a minimum. Collocation of reactors and reprocessing plants helps to achieve this.

As we begin to deploy breeders we ought to site them insofar as possible along these lines in the full realization that we may be committing ourselves to a siting policy that will prevail for an immensely long time.

The siting policy I espouse – relatively few numbers of very large sites – may be evolving inevitably. As it becomes more and more difficult to find new sites, the existing sites will expand. In the Soviet Union sites for 10×10^6 MW(e) are planned, and in Canada such siting policy seems to prevail. We at the Institute for Energy Analysis have found that some 80 of the 100 existing U.S. sites are well located with respect to cooling water, low local population and high future power demand and could be expanded to a capacity of 20,000 MW(e). We also estimate that the entire asymptotic nuclear enterprise in the U.S. could be managed with a commitment of no more than 13,000 km^2. This would be reduced if ocean siting were used; and I believe ocean siting will be necessary in some parts of the world.

Siting alone is insufficient. In addition, security standards will have to be strengthened – which is easier if collocation is adopted generally. But perhaps most important is the strength of the corps that deals with nuclear energy. Our technology is different, and we would do well to admit this instead of denying it. Fifteen billion curies of radioactivity in a 1000 megawatt pressurized water reactor is something very special indeed, and the training and professionalism required of those who handle nuclear energy is and will always be extremely high.

And a good part of the justification for large collocated sites comes from the strength of the cadre that inevitably develops in such centres: such cadres were developed at the U.S. sites – Oak Ridge, Hanford, Savannah River, Idaho Falls. If in final analysis the safety of the nuclear system depends on the strength of those who man the system, I would insist that we enhance the strength of the nuclear corps by centralized siting, and we therefore improve the safety of the system.

Breeders and Proliferation: The Ultimate Question

The future is uncertain: No one can say that the measures I suggest – collocation of breeders in dedicated sites, added security, strengthening of the nuclear corps – will be sufficient to restore confidence in nuclear energy

among those who have lost that confidence. I hope it will. On the other hand, the path that seems to be taken in some quarters – which is a rejection or at least deferral of the breeder – appears to me to add to our uncertainty, not diminish it. Breeders when first discussed 35 years ago at Chicago were viewed as the ultimate aim of nuclear energy. But *when* they would be needed puzzled us then because we knew neither future energy demand nor uranium resources. We still know none of these with certainty – and it is these uncertainties that the breeder eliminates. This has always been a prime argument for early introduction of the breeder. Though our good friend Bennett Lewis has often argued that breeders are not necessary, I believe even he would concede that *if* breeders work and become practical, then they simplify the nuclear system – they trade off complexity in the fuel cycle for the greater complexity and uncertainty in procurement and enrichment of uranium. Most of us figured this was a good exchange, though not all believe the LMFBR is the sole direction for breeder development. Moreover the idea that breeders confer a measure of energy autarchy always seemed attractive to some of us.

We are now in the throes of full confrontation with the threat of proliferation posed by the breeder. All in the nuclear community know that the breeder is by no means necessary for proliferation – that there are more direct routes such as dedicated reactors and centrifuges. Proliferation is therefore in large measure a political issue that fundamentally must be dealt with politically.

Yet I think the technical community must not dismiss the matter so easily. We do have a serious responsibility to devise those breeder technologies or systems that minimize the possibility of diversion. We cannot solve the proliferation problem; but can we not at least separate proliferation from power production?

I cannot pretend to have clear answers. After all reactors and reactor systems have not been designed to be proliferation or diversion proof. And, just as some reactors may have a lower a priori melt-down probability than others, I suppose some reactors and reactor systems may be more diversion proof than others. Explanation of such possibilities we ought to accept as a challenge.

But this much seems clear to me – that a collocated, centralized siting system has the possibility of incorporating barriers to diversion that are less easy to visualize in a more dispersed system. Is it unreasonable to imagine that in a fully developed centre there will be full-time, permanent IAEA inspectors who can know intimately and in detail exactly what is going on at their site, and who can set into motion the appropriate actions, including notification of the Security Council, should they detect diversion of fissile material? This is the kind of semi-technical invention that I believe is possible and that we shall have to address seriously.

I have called my talk "Nuclear Energy at the Turning Point", it is being given on the 20th anniversary of the International Atomic Energy Agency.

Our enterprise is at a turning point in large measure because the issue of proliferation – the same issue that bedevilled the world 30 years ago and gave rise to ideas for total internationalization of the atom such as the Acheson-Lilienthal plan – has once more assumed such large proportion. It may well be that in some sense the world can live comfortably with nuclear energy only by reinventing some version of the Acheson-Lilienthal plan. Have we not taken a first step in that direction with the establishment of IAEA and the NPT? I suspect that whether nuclear energy itself will prosper in ways we have always dreamt or will always be a source of contention and concern because we cannot deal with proliferation – that this in a practical sense will depend on how effectively IAEA can fulfil and indeed, expand its mission. It will take imagination, it will take courage, it will take luck. The future may well depend on how successfully we can respond to the political, even more than the technical challenge posed at this turning point in nuclear energy.

VII. A VIEW FROM OUTSIDE THE U.N. CONFERENCE - "DECLARATION FOR A NON-NUCLEAR FUTURE"

(The following declaration was prepared at a Conference for a Non-Nuclear Future, held at Salzburg, three days prior to the U.N. meeting. The Conference was organized by the European Environmental Bureau, Friends of the Earth International, the Japan Congress against A and H Bombs, the Natural Resources Defense Council, U.S.A., and the Austrian Federation for the Protection of Nature. It was attended by nearly 100 persons representing 20 countries, and was the first international meeting of movements against the use of nuclear power.)

We are citizens from 20 countries throughout the world. We differ widely in wealth, in political opinion, in religion and in cultural experience.

But we share a common concern and a common hope.

Our concern is that the present and future well-being of mankind is being needlessly endangered by the decisions of governments to continue the use and development of nuclear power.

Our hope is that mankind will act in time to prevent further irrevocable commitments to a nuclear future. We are part of a global wave of opposition to nuclear power which is growing in force and which has recently moved some governments to review their nuclear policies. We therefore feel a responsibility both to explain our cause for concern and to demonstrate the availability of a non-nuclear world.

Listening to the voices from Hiroshima, Nagasaki and Micronesia, we share the widely held belief that the proliferation and indeed the continued existence of nuclear weapons threatens the future of all people, and that current progress towards general disarmament is totally inadequate. Moreover, nuclear proliferation is only one aspect of this global problem.

Nuclear weapons can be made from a few pounds of plutonium or uranium. Since the purpose of the breeder and the reprocessing of spent fuel is to separate plutonium or equivalent fissile materials, access to these technologies is

access to the capacity to manufacture nuclear weapons. The increasing deployment of these technologies will dramatically increase the risks of nuclear warfare.

New technologies involving lasers and centrifuges are being developed for the purpose of reducing the cost and increasing the efficiency of enriching uranium. The commercial development of these technologies represents a danger to world security, as does the absence of adequate safeguards on the production, storage and international shipment of natural and low-enriched uranium.

No level of international safeguards which is remotely feasible can prevent a determined government from diverting fissile material into weapons manufacture. Thus the development of these technologies will inevitably facilitate the proliferation of nuclear weapons.

Weapons proliferation is unlikely to be confined to national bodies. The relative ease with which stolen plutonium could be fabricated into a weapon adds a new dimension to terrorism. The measures necessary to prevent thefts, recover stolen plutonium and respond to credible threats must lead to the erosion of human rights with repercussions for the social and political fabric of our societies.

These and other considerations lead us to reject the breeder reactor and the use of plutonium or other bred fissile materials as nuclear fuels. Reprocessing of spent fuel is therefore unnecessary, uneconomic and undesirable, and all spent fuel has to be securely stored.

Thermal reactors, which form the heart of the present nuclear programme, pose major unresolved problems of proliferation, safety, environmental protection, occupational health and radioactive waste disposal. It is these hazards which have generated the growing public distrust of thermal reactors.

Moreover, the economic case for their further deployment does not stand critical examination. Nor are nuclear reactors essential to the creation of full employment: indeed, they may be inimical to it.

In order to achieve a non-nuclear future as soon as possible, we believe that the building of any further nuclear facilities should be strongly resisted, and that all governments should forthwith adopt energy policies which provide for the replacement of nuclear power by alternative energy sources as soon as possible.

Those governments, institutions and individuals who assert the necessity of nuclear power do so on the basis of a fundamentally mistaken conception of energy policy, which confuses costs and benefits and neglects to consider the end uses of energy.

We believe that energy policies should be conceived in terms of doing more useful work with less energy, of matching production means to end-use needs, and of reducing vulnerability to interruption. Such policies do not require the use of nuclear power, yet they would be adequate to the needs of the whole world.

In the developed nations such policies would rely primarily on the reduction of energy waste (for instance by actively supporting the introduction of cogeneration and stopping inappropriate uses of electricity) together with the forceful development of alternative energy sources, in particular diverse forms of solar energy. This must involve diminishing the energy growth of these nations and in the long term stabilising their per-capita energy use.

In the developing nations centralised electricity generation is no more a priority than in the developed world, and will tend to exacerbate rather than ameliorate the problem of meeting basic energy needs, especially in the villages of the Third World where half of humanity lives.

The energy needs of the developing nations could be met primarily by solar energy, biogas and other decentralised technologies.

Furthermore, nuclear power increases rather than decreases the dependence of developing countries on the industrialised world, while widening the disparity in wealth between them. We cannot see that any global energy strategy which fails to assist a more equitable distribution of wealth could, or should, succeed.

Such a highly centralised and capital-intensive technology as nuclear power leads to a further concentration of economic and political power in all nations.

Compared to nuclear power, the technologies we propose are – for all nations – cheaper, more reliable, easier to deploy, less disruptive of existing social and cultural patterns, more equitable, less damaging to the environment and more amenable to democratic control.

We are unanimous in our conviction that a non-nuclear future, based on the policies we are advocating, offers people a more secure and a more humane world. We believe that such a future is not only possible but widely desired throughout the world, and to this end we call upon concerned citizens everywhere to demand by non-violent means that international institutions and governments shall,

– immediately close down all fast breeder reactor and fuel reprocessing facilities, and end the development and sale of such facilities,

– immediately develop specific programmes for phasing out all thermal reactors as soon as possible,

– immediately halt development of technologies for enriching uranium by means of lasers and small and efficient centrifuges, and add an international escort service for shipments of all nuclear materials between nations to the safeguards functions of the IAEA and EURATOM,

– divert the funds and human energies released by all these shifts of priorities into the deployment of those alternative technologies which are already available,

– establish a substantially funded international energy organisation charged with the development, promotion, and transfer of non-nuclear energy technologies, which should not be based on the existing IAEA (although the IAEA and EURATOM should continue to strengthen and perform their safeguards function for as long as necessary),

– redirect development assistance in favour of non-nuclear energy technologies,

– develop widespread mechanisms for public participation at all levels of energy policy decision-making. Such mechanisms should pay special attention to the needs of workers, women and other groups who have uniquely valuable perspectives to contribute.

Emotional and personal involvement have been defined as "unscientific" and "irrational". In fact, issues which concern the lives of human beings must be defended with emotion and personal commitment: they must not any longer be only the subject of abstract calculations. In questions of this magnitude, we may not be detached. We must be partisan.

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This declaration represents the common ground of agreement between the delegates of many nations. Inevitably differences in political tradition and national circumstance create differences in emphasis on some arguments and differences in approach to the handling of the issue. These differences should not be interpreted as any weakening of our resolve to pursue by all possible non-violent means the early arrival of a non-nuclear world.

VIII. AN EXCHANGE OF VIEWS WITH A CRITIC FROM THE FEDERAL REPUBLIC OF GERMANY

May 19, 1977

Dear Dr Abrecht,

I have read the press reports and accounts of the World Council of Churches' position at the IAEA Conference in Salzburg with some consternation. Although I have not yet seen the full text of the written submission I have written the enclosed criticism, at the request of a German journal. There is only one thing that I wish to add to my comments there. One cannot argue with the view of the problems outlined in the paper; what is dangerous, however, is the fact that the W.C.C. rejects the idea of a moratorium in very undifferentiated and sweeping terms and this could have an extremely adverse effect on the practical and tactical position of all church and non-church critics of the premature development of nuclear energy.

You may be sure that I shall make every possible effort to draw attention to this weakness in the paper presented on your authority in the debate surrounding this issue in Germany. It would be a great help if you could send me the full text of the paper submitted in Salzburg.

I also fear that the arguments for the further development of nuclear energy put forward on behalf of the developing countries will not stand up in the long run and will, however unintentionally, turn out to be a subtle reinforcement of western industrialized interests.

My reaction probably comes as no surprise to you, but I should very much appreciate it if the critical dialogue between us could be continued.

Yours truly,
Günter Altner

Nuclear Energy as seen by the World Council of Churches
(A comment by Günter Altner in *Evangelische Kommentare*, no. 6, June 1977)

On May 9, at the Conference on Nuclear Energy held by the International Atomic Energy Agency (IAEA) in Salzburg, the World Council of Churches submitted a written paper which contained some surprising aspects. It dealt in a factual and balanced way with the well-known problems surrounding the use of nuclear energy (the need for public debate, risks of nuclear technology, general access to nuclear techniques, military and social implications, ethical and religious issues). Its main contentions were that we have to make the best of existing developments, insist on the introduction of additional security measures and ensure that nuclear energy production as a whole does not become an end in itself.

A statement like this must have come as a very welcome intervention to the experts representing the producers' side at the meeting in Salzburg who no doubt felt that if this were all the Church's objections amounted to, they could live with them quite comfortably and have nothing to fear from that quarter. If the Church must interfere in things which do not concern it then the least it should do is to make a moderate plea for values that are generally neglected. Where are the radical anti-expansionist ideas we are in the habit of hearing from Geneva speakers on any and every issue? Should we not be trying to hinder the opening of 'Pandora's box' as much as possible? This is the question one longs to ask the authors of the paper submitted in Salzburg. Are we supposed to be appeased by the assurance that there will be no quick solution to the nuclear dilemma? What about the people who continue to be resolutely opposed to the use of nuclear energy? And where is the Church's field of action and pastoral concern in this polarized situation?

The premises and the conclusions of the document submitted by the World Council of Churches must be called in question. Obviously, no sensible and responsibly-minded person is going to advocate a halt to nuclear energy production and renunciation of nuclear technology from one day to the next. But there has to be really intensive debate about what is to be done in the medium and long term, and what must not be done under any circumstances. We have other medium- and long-term alternatives available and to fail to make this clear is to act irresponsibly. In particular, the introduction of the fast-breeder reactor and a plutonium economy are by no means unavoidable. The more emphatic the rejection of it today, the greater will be the chances of avoiding the evil and finding other solutions that are less damaging to life.

Pandora's box can never be shut tight, but the point is to stop the lid from springing wide open uncontrolled, and the way to do that is not to start by releasing the hinges which still hold it, even if they are loose already. Unless the churches' intention is simply to conduct a platonic discussion of the issues, their place in the controversy surrounding the development of nuclear energy production can only be alongside those who are opposed to it on considered grounds and out of concern for its effects on life. (This is not the place to enter into discussion and assessment of the variations of this opposition.) If this is not done in the controversy about nuclear energy, the ground that has been gained in the limitation of extent and delay of time schedules will simply be thrown away.

It made neither good sense nor good tactics for the W.C.C. to append a rejection of the moratorium to the considerations it put forward in Salzburg. A compromise to benefit all the parties involved, be they of present or future generations, developing or industrialized countries, man or beast, will only be reached when all the positions are clearly defended and agreement on a solution to the tensions between conflicting interests becomes unavoidable. To begin too soon to make conciliatory gestures is to cause the complete breakdown of any constructive confrontation between the opposing forces, in any case unequal enough as it is, and to serve the interests of those who are intent on asserting themselves economically by means of the nuclear industry.

There can be no doubt that the World Council's interventions in the nuclear energy debate are above all intended to defend the interests of the countries of the Third World. But this is precisely where the naïveness of the plan shows. Nuclear energy is a force belonging to the economic hegemony of the industrialized states, and will remain so. In the long term it has an intolerable destructive potential for the whole human race. Surely it cannot be right for the churches to come to terms with it.

May 1977 Günter Altner

Letter to Prof. Dr. Günter Altner, Heidelberg, (June 14, 1977)

Dear friend Altner,

. . . I have read with interest your comments on our presentation in Salzburg. May I reply to various points as follows:

1. A reading of the full text of the W.C.C. paper will make it clear that we do not say an unqualified "yes" to nuclear energy. But in all of our studies, beginning in 1974, we have not been able to say an absolute "no". Those who have followed the World Council's discussions of this question will not be surprised that we take a critical but not a completely negative position to nuclear power. I may point out also that the ideas presented at Salzburg were discussed in summary form by the Central Committee of the World Council in August 1976, and that the Central Committee authorized the Departement on Church and Society to make a presentation on these lines to the Salzburg Conference. (For a copy of the German text of the summary paper approved by the Central Committee see *Die Frankfurter Rundschau,* March 31, 1977.)

2. The IAEA deserves credit for being willing to have at Salzburg a plenary session on "Nuclear Power and Public Opinion" with all view-points represented. The major presentations were by: Prof. Hans Bethe, U.S.A., Nobel Prize scientist speaking *for* nuclear energy; Prof. Hannes Alfvén, Sweden, a Nobel Prize scientist speaking *against* nuclear energy; and the paper from the World Council of Churches. Is it not important that an international technical agency like the IAEA begins to take seriously the social and ethical implications of nuclear energy? It was not by accident that they put this topic on the programme; and having put it on the programme they decided to ask someone outside their own technical and political circles to chair that session and approached the World Council of Churches. Should we have refused? I think we were asked because they trusted our concern to take seriously many different points of view. I enclose for your information my remarks as chairman and also the paper by John Francis who made the presentation for the World Council of Churches.

3. I think when you read the W.C.C. paper you will see that our position on various points is much more carefully defined than you have assumed it to be. I take one example: the issue of a moratorium. Contrary to what you say we do not reject a moratorium. We say that a moratorium under certain conditions could be useful action.

4. I note especially your remarks about the Third World. The question is, what is the Third World's own view? To my knowledge, the World Council of Churches is the only organization that has seriously tried to involve Third World view-points in the debate about nuclear energy, and what we say in our documents represents Third World opinions. Do you know what the Third World is saying about nuclear energy? It is clear that many in the Third World do not believe that our western societies will reject nuclear energy, whether for weapons or for civilian use. Their objective then is to insist that nuclear technology be shared with them and that the use of nuclear technology in the future be looked at as an international responsibility and not only as the responsibility of the countries now possessing nuclear technology. In other words there is a political problem here which you skip over in your remarks.

5. One final comment. We do not in any way challenge the integrity of those who are against nuclear energy and we respect their reasoning. But we are distressed that individual Christians and Christian groups in Germany have contributed to the polarization of this debate and have failed, apparently, to work for a truly ecumenical approach. Without this a certain type of self-righteousness develops on both sides. I hope that you and others will press the churches in Germany to make possible soon an ecumenical examination of this question.

Be sure that I am eager to have your further comments and reactions. The Salzburg paper is not the last stage but only a further development of ecumenical thinking. The Central Committee of the W.C.C. has recommended that this debate continue in order to clarify the technical, moral and spiritual issues involved. When they meet in July (1977) they will look again at the state of the debate and recommend further steps. We shall report on the reactions from you and other friends following the Salzburg discussions. My own conviction is that the churches must prepare for a further extensive discussion of these questions. The energy issue in general and nuclear energy in particular will no doubt be one of the main concerns also of the 1979 World Conference on Faith, Science and Society. . .

Paul Abrecht
Director, Church and Society

IX. THE W.C.C. AND THE NUCLEAR DEBATE - NEXT STEPS

(Recommendations of the Central Committee of the World Council of Churches, Geneva, August 5, 1977.)

1. The Committee has received with great interest the report of the W.C.C. delegation to the Salzburg Conference on Nuclear Power and its Fuel Cycle organized by the International Atomic Energy Agency; and has seen the papers presented at this Conference by the W.C.C. in a highly competent and effective way, along the lines proposed by the Central Committee in August 1976. It was also noted that it was an unusual privilege for the W.C.C. to be invited to chair the Plenary Session on Nuclear Power and Public Opinion at the Conference.

In view of the fact that, in the course of the past year, the development and location of nuclear reactors has become an increasingly contested issue in several nations, and has shown the urgent need for church leaders and individual Christians to have more information and clearer awareness of the issues involved, the Committee *recommends* that the sub-unit on Church and Society organize a Consultation on "Ecumenical Concerns in Relation to Nuclear Energy", keeping in mind the following points:

(a) Representation should be balanced: i.e. pro-nuclear, anti-nuclear, and undecided positions, as well as nuclear nations and non-nuclear nations, communities affected by activities relating to the nuclear fuel cycle (i.e. uranium mining and enrichment, reprocessing, waste disposal) or by the location of nuclear reactors in their vicinity, etc.

(b) The Consultation should focus on the use of nuclear power for peaceful purposes, in the context of world energy needs and possible resources, and in light also of the concern for a Just, Participatory and Sustainable Society. This Consultation would also constitute part of the preparation for the 1979 World Conference on Faith, Science and the Future.

(c) The Consultation should keep in mind that, as the Central Committee said in its *Statement on Nuclear Energy* in 1976, "The predominant issue concerns the operation and safe management of breeder reactors without which nuclear fission has no long term existence"; and examine the basis for assurances to the public on the security of the fast reactor technology.

(d) It should analyze the grounds on which local communities have objected to nuclear reactors, e.g. whether they are opposed in principle to nuclear energy; or only until proper technology is available for the safe management of long-lived radio-active wastes; or opposed only to breeder reactors; or only to the location of reactors in their vicinity.

(e) Besides providing for the sharing of information and the clarification of issues, the Consultation should also aim at the further development of an ecumenical position and the formulation of programme recommendations for the churches.

2. The Central Committee noted that the violence that sometimes attends demonstrations against nuclear energy or nuclear reactors (as in Malville, France, during this Central Committee) points to the degree of emotion associated with the immense interest in the issue, and urges the sub-unit (on Church and Society) to do everything possible to promote a sane and informed discussion of the issues involved. It affirms that decision-makers in all countries cannot avoid open public debates on such issues nor should they allow themselves to be guided by strictly economic interests on these matters.

3. The Committee requests the Energy Advisory Group of Church and Society to explore two specific needs and possible answers to them:

(a) To examine the role of international bodies like the International Atomic Energy Agency in correcting present imbalances and systematic discrimination against non-nuclear nations in securing access to nuclear technology, keeping in mind the relation between the peaceful use of nuclear energy and its potential military use.

(b) To consider the advisability of some new international commission or panel that might respond to situations of perplexity, conflict and polarization on nuclear energy by fact finding, providing information, advising or mediating in conflicts, as requested, e.g. by local or national councils of churches or other community groups. Any proposals for action should be reported to the next meeting of the Executive Committee of the Central Committee.

PART TWO:
THE CONCERNS
OF CHURCHES

I. THE PROLIFERATION OF NUCLEAR TECHNOLOGY

JOHN S. HABGOOD, BISHOP OF DURHAM

In recent months there has been an explosion of public interest in nuclear technology, partly sparked off by the publication of the Royal Commission Report on Nuclear Power and the Environment, and partly in response to Mr. Benn's plea that there should be widespread debate on the subject. Awareness that a Government decision may be imminent on whether or not to start the next stage of the nuclear power programme by building Fast Breeder Reactors has no doubt also been a factor in keeping the subject in the news. Whatever the reasons, hardly a day passes without some mention of the topic in the newspapers, and it may therefore be useful to have a broad, non-technical review of the issues from a Christian perspective.

The World Council of Churches has already produced two major studies on nuclear technology, one in preparation for, and the other resulting from a Conference held in June 1975, at Sigtuna in Sweden. A number of individual churches have mounted their own studies. For instance, the Church of Scotland held a Conference in August 1976, under the title Infinite Potential or Infinite Risk? , which came to broadly the same conclusions as the United States National Council of Churches of Christ in proposing a moratorium on the further developments until the issues and the alternatives to nuclear power are better understood. The W.C.C. was more cautious in its general conclusions:

"Our group cannot put forward categorical recommendations. It would not feel justified in either entirely rejecting, nor in whole-heartedly recommending large-scale use of nuclear energy." One could scarcely be more judicious than that!

A factor inhibiting many from taking part in the debate may be fear about the technical complexity of the subject. The Royal Commission Report is admirably clear and introduces its main themes in a style which should be reasonably comprehensible to those without specialist scientific knowledge. But there is no denying the fact that technical considerations are of crucial importance in any informed ethical discussion. Ethics is not a study in vague generalities, but must take account of the actual complexity of things as they are.

This is not to say, however, that there can be no simplification. Indeed, my aim in this paper is to try to tease out the underlying issues of principle, and set them within as broad a context as possible. It is by scrutinizing the value judgements underlying complex choices, and by trying to assess these within the context of God's world and His purposes, that the Christian thinker can make his best contribution to the current debate.

During the summer of 1976 I visited the British Nuclear Fuels Reprocessing Plant at Windscale, and ended the day by leading a discussion between some sixty or so Church members employed in and around the Windscale Plant. The discussion achieved a minor breakthrough in that it was the first time that the exponents of very different views on nuclear energy had met there in reasoned argument; the success was largely due, it seems, to the fact that the context was deliberately made as broad as possible, and so lifted above the level of local politics. The immediate pressures were strong. It was obvious, for example, that there were many local fears of pollution on the one hand, or unemployment on the other. There was also a certain defensiveness among staff employed in the Plant about the criticisms to which they were subjected in the Press and by bodies like Friends of the Earth, and there was clearly no wish that Windscale should become another Aldermaston.

It became possible to face the issues constructively when we stopped arguing about minor degrees of pollution and infinitesimal risks, and tried to think instead what the world might be like in thirty or forty years' time when there could be as many as three thousand Fast Breeder Reactors meeting a major proportion of the world's energy needs. It is at that stage in development that questions about the maintenance of standards in work which would by then have become routine, begin to become serious. Those with no doubts about our present nuclear installations may well be fearful of the time when the stimulus of a pioneering phase in development is over, and the motivation for safety-consciousness has declined. On the other hand, those employed in the industry were quick to point out how favourably their record compared with those of other dangerous industries, and they wondered why nuclear technology was especially singled out and subject to such unusual standards. It was clear, however, that even a even a long-term look at the issues in terms of safety did not get to the root of the matter.

Our discussion led us to see that the underlying choices are social, ethical and political. What kind of a society do we want to bequeath to future generations, bearing in mind that we now stand at a kind of watershed in technological development? Two rivers, originating at the same point and running down different sides of the mountain, may flow into quite different seas.

The Main Technical Considerations

Before looking at the broad social issues, though, I must first summarise the main technical considerations entailed in the choice which has to be made:

1. **Future Energy Requirements:** Everybody agrees that in twenty or thirty years' time the gap between energy consumption and the energy produced from conventional fossil fuels is going to be uncomfortably wide. There is no agreement, though, on how wide it is going to be, nor on the possible scale of future requirements. In its evidence to the Royal Commission, the U.K. Atomic Energy Authority predicted a sevenfold increase in energy consumption between 1975 and 2030. It estimated that during that period the proportion of total electricity consumption generated by nuclear power would need to rise from 9.5% to 97%. The Royal Commission questioned these figures and proposed an alternative strategy in which consumption would only rise by 40% during the period, nuclear energy providing about 30% of the total. The Commission suggested that this modest increase could be achieved by a much more efficient use of energy and without drastic cutbacks in the rate of economic growth. It made a particular point of the inefficiency of electricity generation, an inefficiency inherent in the process, but which could be substantially reduced if the heat now dissipated by power stations was used, for example, for district heating schemes. This would entail siting power stations near centres of population.

The so-called Marshall Report on Energy Research and Development in the United Kingdom set out seven possible scenarios covering the next twenty-five years, and concluded that at an annual growth in energy consumption of 2.4% nuclear energy would be indispensable, but that at a 1.1% growth rate it would not be needed up till the year 2000, but thereafter would almost certainly be needed by 2025.

Differences of opinion of this order of which these are only a few examples and in which so much depends upon one's initial assumptions, mean that no firm forecasts are possible. What is certain, however, is that on a world scale the consumption of energy is going to increase vastly. At present the energy consumption per capita in the United States is the equivalent of 11,500 kilogrammes of coal per annum. For Bangladesh the figure is 32; Western Europe has an average of around 4,000; otherwise, the only countries in the world which exceed 1,000 are Japan, Kuwait and Israel. On any reasonable assumptions about world development, the energy needs of the majority of less favoured countries are going to increase many times. Since this development will be taking place during a period when the price of fossil fuels will be rising, there will be strong pressures in favour of using nuclear energy. Fast Breeder Reactors in particular will have enormous attractions, since their highly efficient use of uranium as their basic fuel could mean virtual self-sufficiency in energy terms for countries which process them, and can do the necessary re-processing. This would in turn provide a certain security against inflation.

In the long-term, the dream of unlimited energy supplies depends on the successful exploitation of nuclear fusion. The hope is that the process might be free of long-term radio-active products, and use as its fuel an isotope of hydrogen which is present in enormous quantities in sea-water. And an extremely potent dream it is likely to be. The appropriate technology may not be ready for thirty years or more, if ever, but countries with limited energy supplies would need strong alternative reasons if they are not to pursue this as their ultimate goal.

2. **Risks.** It is convenient to think of these in three broad categories:

(a) *The dangers inherent in routine operation.* There is no reason seriously to doubt the assurances given by those in the nuclear industry that at present the risk of any escape of radio-active materials from one of their plants is very small, as is the risk of a major catastrophe. Radio-activity has the advantage of being easy to monitor, and I believe that the industry is right to contrast its extremely high standards with those in other potentially dangerous fields.

However, as installations multiply, and as the potentially more dangerous Fast Breeder Reactor comes into widespread use, the risks will multiply too. In these circumstances the degree of commitment and self-discipline required among those engaged in the industry will be enormous. It is a safe working rule to assume that any accident, however unlikely in theory, will eventually happen if there is any scope left for human error.

We rightly demand extremely high standards of safety in the nuclear industry because of the nature of the risk. The results of explosions, or of the release of pollutants, in other industries can be devastating in the short-term, but there is nothing comparable to the possible long-term effects of any major release of radio-activity. High standards are also demanded when the general public is at risk, in addition to those actually employed in the industry concerned. It also seems that risks are psychologically less acceptable when those exposed to them have no control over them; thus individuals will take risks with their own lives when driving a car, which would not be tolerated in a bus; and still less in a train where the driver is even more remote from the passengers. In the case of nuclear energy, a risk over which future generations might have no control for thousands of years seems particularly abhorrent.

On the other hand, human beings are risk-taking creatures, and although the risks in nuclear processes seem peculiarly sinister, they are, nevertheless, well understood – perhaps better understood than many which are accepted much more casually. Furthermore, if the nuclear programme were to be abandoned, and reliance placed on other sources of energy, there could well be risks entailed in its use, of which at present we have no conception. The suggestion in a recent book that the world might have a hydrogen economy by using sunlight electrolysed water, filled a nuclear scientist with whom I was talking with horror. His reaction was that he would rather work on a nuclear pile any day than run his house or his car on bottled hydrogen. Moreover, even if a massive extraction of solar energy was possible, say by using the Sahara as a giant generating station, nobody knows what effects such installations might have on world climate. In other words, there are risks entailed whatever we do, and I do not myself believe that the risks inherent in the routine use of nuclear energy count decisively against it.

(b) *The dangers of pollution by radio-active waste.* The Royal Commission Report concluded that it would not be advisable to embark on a programme of nuclear expansion without further research into the means for disposing of long-term, radio-active waste. Some waste products remain active for a very long time, running into thousands or even tens of thousands of years, and for a considerable part of that time they may generate sufficient heat to make special provision for cooling them essential. During my visit to Windscale I was allowed to clamber over one of the storage tanks in process of construction, where liquid waste will be stored until something better can be found to do with it. Each tank is a huge stainless steel structure with seven independent cooling systems which will have to be kept operational for an unforeseeable number of years. The row of tanks already filled and sealed up in their concrete containers was a vivid reminder that the problem of waste disposal does not only belong to the future.

It is true that various other means of disposal are being actively explored. The most promising of these involves solidifying the residues in glass, and burying them under the sea-bed in some part of the ocean where the geological formations are known to be stable. Even this method of disposal, however, cannot provide a complete guarantee of

protection against pollution over the long periods of time during which some of the waste will remain active.

It has been pointed out that the management of waste over periods of thousands of years demands a longevity in human institutions which none have so far attained. An American nuclear physicist has written: "We have relatively little problem in dealing with wastes if we can assume that there will always be intelligent people around to cope with eventualities we have not thought of.....". In the same article he went on to point out that commitment to nuclear power is a commitment for ever, comparable in importance to primitive man's commitment to agriculture. Once the step was taken, and human institutions had been built, which depended on agriculture for their survival, there was no going back.

If this seems a large decision for a relatively unprepared world to take within the next few years, it is worth reiterating that whatever the decision, the problem is with us now and will remain with us for the foreseeable future. The waste from existing nuclear power plants, which is alarming enough in itself, is dwarfed by the large quantities of waste created as a result of nuclear weapons programmes. It has been calculated that there is already ten times as much waste in existence as will be produced by any conceivable expansion of civil programmes during the next twenty years.

Apart from radio-active waste, there are other pollution problems connected with the generation of electricity in nuclear power stations, and the reliance on electricity as the major source of power. The most troublesome of these is likely to be heat pollution; approximately three times as much energy has to be dissipated as heat as is converted into electricity. The re-siting of power stations so that some of this available heat could be used directly in central heating systems, would run counter to the policy of siting nuclear power stations well away from centres of population. On the other hand, to site all the reactors on desolate coasts and to use the sea for cooling would create environmental disadvantages of another kind.

Pollution, in other words, is a major problem to which no definitive answers have yet been given. However, there is no reason to suppose that acceptable solutions will never be found, and the Royal Commission was surely right to conclude that there is a case for slowing down nuclear development until more research has been done on the subject of waste disposal, but that this is not a reason for abandoning the programme entirely.

(c) *Military risks.* These have received a lot of publicity recently, especially in relation to possible terrorist activities.

Risks from terrorism arise mainly because nuclear power plants are enormously expensive, would be difficult to protect in large numbers, and could be used as a powerful bargaining counter in a successful terrorist raid. The potentional danger from damage or destruction, as well as the damage to the national economy, might make it very hard for any Government to hold out against terrorist demands.

In wartime the risks would be similar, with the added disadvantage of a highly-centralised energy supply which would presumably be a first target for enemy raids.

There has been much debate about the possible dangers resulting from movements of plutonium from reprocessing plants to reactors, and it has been suggested that transport could be hijacked, or small quantities of plutonium spirited away for the manufacture of nuclear weapons. No doubt this is theoretically possible, but the difficulties would be formidable, and it has been argued that a determined group of terrorists would stand a much better chance of manufacturing or obtaining a successful bomb by stealing from military installations rather than civil ones.

Be that as it may, it is obvious that security must play a large part in any nuclear programme. A Friends of the Earth pamphlet has painted an alarming picture of the kind of police state which might develop as the result of the elaborate security precautions and screening procedures which any wide scale commitment to nuclear power would necessitate. It seems to me, however, that the largest threat from nuclear installations resides in the fact that Governments which are committed to nuclear technology can, if they wish, manufacture nuclear weapons. So long as the world is content to live with nuclear weaponry, the military risks created by nuclear power stations though important, remain secondary. It is therefore difficult to counter the argument that those who have learnt to live with the bomb ought not to be too fastidious about the Fast Breeder Reactor.

The risks I have so far described are real and serious, and there are those who feel that the world's need for additional sources of energy would have to be even more pressing than it now appears to be in order to justify running them. On the other hand, it can be claimed that all the risks are of a type which advancing societies have found themselves capable of handling, and that the alternatives are even more hazardous.

The disagreement points to the deeper questions of values underlying the mainly technical issues which have so far been considered. I return, therefore, to the basic question with which I started, namely, what kind of a society do we want?

One aspect of this larger question was pinpointed by the Chairman of the Royal Commission, Sir Brian Flowers, at the National Energy Conference held in June 1976. He said: "We believe that nobody should rely for something as basic as energy on a process that produces in quantity a by-product as dangerous as plutonium." The significance of that remark lies in the phrase "as basic as energy". The argument, in other words, is not about a fringe benefit, however desirable, but about the resource on which the whole of an industrial society depends, and which therefore deeply influences the character of that society. An Indian physicist has written: "Scratch any piece of technology and you will find the values and aims of a society it was designed to serve. For technology is like genetic material – it carries with it the code of the society which conceived it. This is why the choice of technology is such a crucial decision in the developing countries today. The kind of society and the kind of environment which they will create depends to a large extent on what technology they choose for the job of development."

Nuclear energy not only creates new forms of society by enabling industrial and economic expansion to be continued into the foreseeable future. It also implies a certain kind of society, in that it requires a broad technical base to support the highly advanced technology on which that society's primary resource must depend.

This consideration about the kind of society implied by nuclear technology may be equally valid if and when fusion reactors become a practical possibility. It is often assumed that the problematic nature of nuclear technology arises mainly from the risks associated with a Fast Breeder Programme, and that these will virtually disappear when fusion power comes on the scene. The social implications, however, will remain. These will differ in character, though, depending on whether workable fusion reactors turn out to be very large, or whether fusion by means of laser beams leads to the development of small localised power plants.

Some Social Implications of a Nuclear Energy Programme

1. *In developed countries.* An expanding nuclear programme might provide a strong temptation to suppose that the general rate of economic expansion in developed countries

could continue without interruption. Whether or not this would be tolerable in terms of other resources besides energy, and whether continued expansion would simply increase the disparities between rich and poor countries is one of the major social and political questions facing the industrialised world today. The World Council of Churches' studies on this theme have developed the idea of "the sustainable society" within which the rate of expansion has been reduced either to zero, or to a figure which could be sustained for the foreseeable future.

It is possible to envisage a sustainable society which makes use of nuclear energy, and to that extent decisions about the one are separable from decisions about the other. Nevertheless, the fact that far-reaching decisions have to be made about nuclear energy provides a unique opportunity to think deeply about long-term aims for society, at a time when the risks of continued expansion are clearly seen, and the doubts about energy supplies have not yet been silenced by a massive commitment of capital to a particular solution. No solution is without its hazards, and the move towards a sustainable society, with or without nuclear energy, would carry particularly severe social ones. Would people stand for a slowing down of our present social economic machine? What would be the effect of a gradually decreasing growth rate in terms of jobs, standards of living and the general health and security of society? Are longings for a simpler life-style confined to those who have already had their fair share of this world's goods, and would a cutback now seem like the ultimate betrayal to those who have just begun to get their feet on the ladder of prosperity? Are we caught in a technological trap from which there is no escape except into more technology? If it is claimed that it is possible to say 'no' to continued expansion, and to the nuclear programme which would have to undergird it, we have to face the fact that, in the words of John Francis, "there is not a single example in which mankind has currently succeeded in holding a rapidly advancing technology at arm's length", mainly because the political and economic incentives for continuing in our present direction are too strong.

2. *In developing countries.* The same long-term considerations apply in developing countries as in developed ones. There is the added complication, however, that some developing countries see nuclear power as a guarantee of their own independence. For example, a spokesman from Latin America, writing about the exploitation of coal and oil by the industrialised nations adds: "That history is not going to be repeated in respect of nuclear energy. This means that we are not prepared any more to just wait and see what the powerful nations are going to do.... Nuclear energy has really inspired the idea of self-reliance in the technological sector that is now spreading all over the world." He goes on to say that developing nations are quite prepared to make their own mistakes.

Such independence, of course, if achieved would be relative, not least in a cultural sense. I have already made the point that to import an advanced technology inevitably means importing the cultural background which sustains it. India's programme, which was begun only a year after independence, was pursued at a time of great social need, both as a visible symbol of independence and also as a means of stimulating indigenous science. India also illustrates how a nuclear power programme cannot be separated from a weapons programme. It seems clear that any attempt to force such a separation on developing nations would be deeply resented. It would strike at the heart of the very self-reliance, both economic and political, which the nuclear programme would be designed to achieve.

One of the alarming features of the nuclear age would lie in the concentration of political power it would encourage, and this fact must be set against all talk of independence. Does independence mean independence for people, or for their political rulers? We have already seen in Britain how the centralization of energy supplies puts enormous power in the hands of a very small number of people, whether the legitimate government, or those determined to influence it. There is also the point already mentioned about the degree of surveillance needed over nuclear installations and the transport of nuclear fuel, and the political implications which flow from this. The international dimension of nuclear control might, if handled wisely, lead to a greater sense of world community and a more just distribution of resources. Unfortunately, it could just as easily lead to an increasing gulf between rich and poor, and a heightened authoritarianism.

Conclusion

In the end the choices made by individuals and by nations will probably depend on ill-formulated beliefs about human nature, and it is on this level that Christian insights can perhaps be of most help in clarifying the issues. Are human beings resilient enough to cope with the unprecedented problems of a nuclear age and the permanent commitment which this would entail? Alternatively, is this possibly our last opportunity to reverse the current trends? Which is more fundamental as a type of Christian response – thrusting creativeness or a humble acknowledgment of human limitations?

The concept of stewardship has been fruitful in recent Christian discussions on these themes. It implies a sense of responsibility concerning the resources entrusted to us, as in the parable of the servants who doubled their capital, while denying that human ambitions can be the sole criterion for deciding how they should be used.

My own belief is that we have for too long identified the creativeness for which man was made, with scientific and technological advance, and now need to place greater emphasis on the kind of moral and spiritual restraints within which it must be exercised. At the heart of Christian affirmation of the world there is an element of holding back, supremely exemplified in the central Christian doctrine of Incarnation. Within the overflowing of divine love there was a scaling-down to human limitations – "Being in the form of God.... He humbled Himself, taking the form of a servant." Love shows itself as much in what it does not do as in what it does.

Is there a clue here about the basic frame of mind in which to approach these enormously complex decisions? The expression of doubts about the nuclear power programme may be an important reminder of the need to recover a sense of restraint in many other features of our social and political life. It is thus not inconceivable that there could be a moral feedback in what would be an undeniably courageous political decision.

This is not to deny, however, that a decision by the United Kingdom not to proceed with an expanded nuclear programme, could be made on purely pragmatic political grounds. I believe it could be a sensible decision even if, as seems likely, many other countries choose differently. In the first place, by foregoing a Fast Breeder programme the United Kingdom could be free to put capital into the development of other energy resources which might, at a later stage, be of great benefit not only to ourselves but to developing countries in other parts of the world, or even to other industrialised nations if unsuspected snags appear on the nuclear front. Britain is uniquely well-equipped to pursue such alternatives in view of our large reserves of conventional fuels. Secondly, if in the end attempts to develop these alternatives fail, it would almost certainly be possible to buy

the appropriate nuclear technology at a later stage, in view of the strong likelihood that some countries at least will pursue Fast Breeder programmes. Thirdly, the policy of buying at a later stage might make commercial sense in the light of the organisational difficulties in the present British nuclear industry. Lord Hinton, former head of the Central Electricity Generating Board, writing in a recent edition of *New Scientist,* has said as much, though no doubt more as a bargaining counter than as a serious statement of policy. The implication is, though, that even a man as closely identified with reactor development as he was, is prepared to entertain the idea that Britain might opt out at this stage.

My own conclusion is that we should do so. It is not often that a decision of this magnitude, which is above party politics and which will deeply affect the future of the nation, can unite those who are worried on a purely technological level with those who see deeper social, ethical and ultimately religious issues at stake.

II. BRITISH COUNCIL OF CHURCHES OPPOSES REPROCESSING PLANT

G.S. ECCLESTONE AND DAVID L. GOSLING

Submission by the British Council of Churches to the Public Local Enquiry into an application by British Nuclear Fuels, Ltd., referred to the Secretary of State under Section 35 of the Town and County Planning Act 1971, for planning permission to establish a plant for reprocessing irradiated oxide nuclear fuels and support site services at Windscale and Calder Works, Sellafield, Cumbria.

Introduction

The written submission of the British Council of Churches falls into two parts. In the first we set out the grounds for considering that the application by BNFL for planning permission to build an oxide reprocessing plant raises major moral issues. In the second we give our reasons for concluding that the application should be refused.

1. General Considerations

It is possible in principle to envisage decisions which are purely technical, though it must be said that they rarely occur in real life. Any decision which involves the allocation of resources for example, also involves judgements about foregone alternatives. It is clear from the initial statement by Lord Silsoe, and particularly point 14 (with the balance it strikes between surrendering to terrorism and 'abandoning a source of energy which could do an enormous amount of good') that the applicants acknowledge that the present application involves not only technical considerations, but also economic, social, environmental and political issues and the striking of a balance between them. The process of striking a balance, which must be presumed to have been gone through by BNFL before deciding to submit the application, and which it must certainly be one of the tasks of the enquiry to repeat, necessarily involves the exercise of value-judgements, particularly those bearing on social goals and means used in achieving these goals. It is not in essence a problematic procedure, and we all have extensive experience of it as it applies to decisions in public and personal life; it is necessary however to emphasise that it depends upon the application of values to which one is committed, and a capacity to rank different values in order when considerations conflict one with another.

Such a procedure, involving both the marshalling of all relevant considerations and their evaluation in the light of primary personal and social commitments, constitutes moral evaluation. It is in this sense that the BCC submit that the BNFL application raises moral issues. We are not, that is, urging that the enquiry consider a 'moral' factor which no other applicant to be heard has noted (though it might turn out by the end of the enquiry that some factors which we should consider relevant have in fact been overlooked). There is in our judgement no special factor which is to be labelled 'moral' and which may be included in or excluded from the overall consideration of the planning application according to taste. We are arguing that the *moral dimension* to the issues raised by the present application be acknowledged, rather than left implicit and unexamined. If this is done disagreements may remain; it will however be possible to be clearer about the basis of the disagreements and even possibly to identify in respect of some issues, such as the safety or waste disposal, procedures whereby the disagreements could be overcome.

The BCC consider that it is not only essential for the enquiry to seek to make explicit the underlying values inherent in the differing submissions; a major procedural step should be for the enquiry to achieve a degree of clarity about the hierarchy, or ordering, of those values. The BCC's own position on the substantive issue of planning permission reflects one such hierarchy of values; we acknowledge that any such hierarchy, including our own, is open to scrutiny and criticism.

It may be asked why the BCC attach such importance to the articulation of the values inherent in the cases for and against the planning application, when we acknowledge that they are implied in the preparation of the application and the holding of an enquiry. We consider that the scale of the resources involved; the very long time-scale within which the consequences of a decision to build and operate the reprocessing plant must be counted; the impact of such a decision on related questions, particularly the question whether to build a commercial fast reactor — all these indicate the inter-relatedness of different types of consideration, the magnitude of the decision, and its likely impact on the future of our society. As such we need to

be as explicit as possible about the social and moral values which shape our judgements.

2. The Case against the Application

The BCC base their case against the application in the main on a convergence of social and environmental considerations. We do not, as a 'lay' body, presume to express a judgement on purely technical issues. It is relevant however to note that technical considerations adduced in favour of the application only have weight insofar as there is *substantial* agreement within the scientific community in regard to them. We note that in regard to certain matters which might reasonably be treated as technical such substantial agreement does not at present exist. There is widespread disagreement as to whether existing safety limits on radiation are in fact realistic, particularly if possible genetic damage attributable to radiation is taken into account. The confidence expressed by BNFL in the early commercial success of vitrification is not universally shared. Looking to the wider context within which developments in nuclear technology are set, it may be noted that there is disagreement concerning the order of magnitude and the timing of the 'energy gap'.

We draw attention first to the effect of a decision in favour of the application on the development of alternative energy sources generally. It is of some importance that in framing a national energy policy (which at present we do not have), some promising options should not be foreclosed prematurely because the bulk of the resources for development have been channelled in one direction only. We believe that a decision to expand reprocessing, with the encouragement it would give to the development of plutonium-based nuclear energy generation, would not only foreclose the development of alternative nuclear technologies such as the use of thorium which do not have the same risks of diversion for warlike purposes, but more importantly would effectively limit the resources available to non-nuclear technologies such as solar, wind and wave power. It is of the nature of all decisions that they rule out alternative options: we draw attention to the risks attaching to a decision which has as its unavoidable effect a move towards the adoption of the single most dangerous type of source of energy generation. To avoid foreclosing options for the future is one of the major values which a scientific-technical society ought to seek to safeguard. In the present context it argues for caution, since any further commitment to the recovery of usable plutonium is bound to have immensely long-term and potentially restricting consequences.

This point is reinforced by the fact that the preferred solution to the problem of the disposal of the long-term waste products of reprocessing, namely vitrification, itself has only been developed on a small scale as yet; and is not expected to be available on a large scale until 1985 at the earliest. Even assuming that no snags are encountered in its development on a commercial scale, the proposal to dispose of the vitrified wastes in geological strata or in the deep ocean bed has itself been challenged as a short-term protection which could lead to long-term problems, particularly through erosion or movement, for which there could be no solutions in the long term.

The balance between short and long-term considerations, and our responsibility to the future, are issues to which special attention needs to be given in the present application in view of the very long-life of the waste products. A distinction may be drawn between the character of our responsibility towards the future, and its duration. As to the first, the ecological movement has brought about a recognition that 'those alive at any time are custodians rather than owners of the planet, and ought to pass it on in at least no worse shape than they found it'[1]. As far as duration is concerned, it may be reasonably concluded that our responsibility to the future extends only so far as we can reasonably foresee. In most cases this extends not more than 10 to 15 years ahead. If however it is clear that the adoption or extension of a particular nuclear technology such as is presently under consideration will land future generations with the task of guarding a steadily increasing amount of highly radio-active material for periods in excess of 25,000 years, our responsibility must include that length of time. It represents an entail upon the future in terms of resources committed and inherited liabilities which can only be justified if no less drastic courses are open to us. The BCC does not consider that the circumstances justify our assuming such a responsibility, unless and until a solution has been found to the problem of waste management which demonstrates 'beyond reasonable doubt that at least one method exists for the safe isolation of these wastes for the indefinite future'.[2] We agree with the Royal Commission that to commit future generations to the consequences of fission power in the absence of such a solution would be 'irresponsible and morally wrong'.[3]

Against this background, while acknowledging the legitimacy of considerations relating to the gains to the balance of payments and to local employment which would flow from the enlargement of the existing reprocessing facilities and the reprocessing of wastes from overseas, we cannot regard them as other than short-term, and therefore urge that they be given a lesser weighting. It should however be pointed out in addition that at the time of writing (June 1977) there is little detailed information concerning the Japanese reprocessing contract which has been frequently cited, while Copeland Borough Council in supporting the planning application acknowledge that the short-term impact of the development on employment would be minimally beneficial or even adverse.

The considerations adduced so far reflect a concern to sustain values which are widely regarded as integral to the life of our society. The planning application has however more direct implications for the kind of society we may wish to see develop in the near future. It is an important part of the argument for the plutonium-based fast breeder reactor system that it represents the only way of bridging an energy gap which could lead to intolerable poverty and social breakdown in societies which are at present accustomed to high levels of energy consumption. We have a shared interest in seeing a society develop which enables its members to live more adequate lives and guarantees the basic social needs of peace and order in which humanity can develop. From this standpoint a disastrous energy shortage by the end of the century would be socially and humanly destructive. But it needs to be said that the assertion that the only way of meeting this possible eventuality is by way of a plutonium-based economy is itself controversial; at the very least it leaves out of consideration the option of a closing of the energy gap partly by increased energy supplies and partly by a more thorough-going commitment to energy-conservation than we have yet envisaged. It moreover disregards the likelihood that the requirements of security and centralised decision-making will make a society which is increasingly dependent upon plutonium-based energy generation a less free, and more regimented, society than we at present consider desirable. This is an option which, as in war-time,

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1 B. Barry, in P.M.S. Hacker and J. Raz (ed.), *Law, Morality and Society* (Clarendon Press, 1977) p. 284.

2 *Royal Commission on Environmental Pollution*, Sixth Report, para 181.

3 *ibid.*

we might for a period be prepared in the absence of alternatives and in the interests of some overriding objective to accept. But the BCC do not think that it is legitimate to embark on such a course of action, which brings with it as a distinct possibility the significant limitation of our civil liberties, on any lesser justification.

Summary

The BCC submit that the present enquiry must take account of a range of considerations in such a way as to elucidate the moral character of the ultimate decision. The BCC point to the following considerations in particular:

(i) significant disagreement among experts relating to relevant technical considerations;

(ii) the foreclosing of alternative, and less dangerous, options by a decision to expand a part of the nuclear energy process which gives prominence to the use of plutonium;

(iii) the unwisdom of expanding reprocessing facilities before a satisfactory solution is achieved, on a commercial scale, to the safe disposal of the wastes deriving from reprocessing;

(iv) the added objection to a development which increases the burden of risk to our descendants;

(v) the *relative* insignificance of arguments for the planning application based on foreign earnings and employment opportunities; and

(vi) the prospect that increased production of plutonium, and the possible consequential stimulus to a plutonium economy, will lead to unacceptable limitations on civil liberties.

In the light of these considerations the BCC submit that the BNFL planning permission should not be granted.

III. FRUIT OF THE ATOM - REMARKS ON AN ANTI-NUCLEAR POSITION*

A Plea for Christian Sanity in the Nuclear Power Debate

ERIC JENKINS

'The BCC will therefore oppose planning permission for the oxide reprocessing plant on both counts, and it will do so with a powerful mandate delivered by the almost unanimous vote given for its recommendation by delegates at the spring Assembly.' So wrote David Gosling in issue no. 12 of *Third Way,* reporting on the British Council of Churches' attitude to the current public enquiry about proposals for a nuclear reprocessing plant at Windscale in Cumbria.

Since his article appeared, a press release from the BCC gives the news that 'a written submission by the British Council of Churches to the Windscale Enquiry has now been formally accepted by the Inspector, and the Council has been given the opportunity to present its case in due course'. The formal 'submission on behalf of the British Council of Churches' is signed by Giles Ecclestone, Secretary of the Church of England General Synod's Board for Social Responsibility and David Gosling, formerly a nuclear physicist and now in the Department of Theology in the University of Hull. David's article makes it clear that the BCC's opposition to the oxide reprocessing plant at Windscale is connected with its decision 'at its April Assembly to urge the government not to go ahead for the time being with CFR-1' (the proposed commercial fast reactor, on which Mr Benn has so far withheld his decision) 'until prospects for international co-operation have been further explored, and a solution has been found, for the problem of waste disposal'.

This means that, in the light of the Council's engagement with questions of nuclear energy policy in the last nine months, during which it has held public hearings on CFR-1, studied and debated the development of fast breeder reactors within the broad context of energy policy and drawn on the work of the World Council of Churches' programme on 'Social Responsibility in a Technological Age' and of the Church of Scotland's project on 'Society, Religion and Technology', the BCC has now committed itself to the anti-nuclear camp on both the controversial nuclear issues awaiting resolution in the United Kingdom.

It should be noted also that some UK religious leaders have recently gone even further in their opposition to nuclear power. The *Guardian* of May 2, 1977 carried a full page advertisement bearing an 'Open Letter to President Carter', supporting the President's effort to eliminate nuclear weapons and his new energy policy, but expressing the further opinion of the signatories that 'we fear the spread of nuclear power for several reasons... Even used peacefully, it involves incalculable risks... The drive for nuclear power is an example of a dangerous urge to even greater complexity and size, which takes governments further and further away from the real needs of men, women and children in every community of the world.' Because of their opinions, the signatories advocated further steps to create, 'the right climate for world de-nuclearisation'. The signatories included many well-meaning and eminent people, including writers, broadcasters, lecturers, clergy and bishops.

Such testimony deserves to be listened to with great respect, deeply pondered and prayed about. My own study, discussions and lectures on this subject during the last two years, however, with audiences varying from parish house groups to university theologians and moralists, force me to question whether thoughtful Christian opinion *ought* to be anti-nuclear, in the light of biblical teaching. Personally, I have welcomed Christian initiatives in various interdisciplinary dialogues on nuclear power and have favourably reviewed books about two of them for *New Scientist (Facing up to*

*) Published with the permission of the August 1977 issue of *Third Way*, a fortnightly review, London.

Nuclear Power by John Francis and Paul Abrecht, about the WCC hearings in 1975 and *Nuclear Crisis – a Question of Breeding,* by David Gosling and Hugh Montefiore, about the BCC hearings of 1976). Dialogue is one thing – but outright opposition is another, especially when it appears to be expressed rather hastily, and without a clear elucidation of the basic principles. In this present article I make an effort, as my conscience compels me, to redress the balance of informed Christian opinion in the UK, on theological grounds.

The Providence of God

I should preface my case with the reminder that, to my certain knowledge, the nuclear industry in the United Kingdom contains a good proportion of idealistic, conscientious people – many of whom are active Christians. Two men, for instance, were recently ordained in this diocese to the auxiliary pastoral ministry from the United Kingdom Atomic Energy Authority (UKAEA) complex at Risley. (Of course, it is possible that these 'scientific evangelical Christians' are misled, or that they unfortunately keep their faith and their social conscience in separate and water-tight compartments. I personally doubt it.)

To begin with we should look at the concept of divine providence in and through human history. The Old Testament speaks of an active God who has a hand in battles, in tribal movements, in the building and destruction of temples, in the rise and fall of empires. Someone once advised Christians to read newspapers 'to find out what God is up to in today's world'. Dare we ask then, 'what has God been up to in the processes of scientific discovery during this century? ', in particular, in the completely unexpected discoveries of radioactivity, nuclear disintegration and eventually of nuclear fission. In a fallen world, this has led on the one hand to the ever-present threat of nuclear holocaust, on the other to a promise of a significant extension in energy supply in an era when fossil fuels are facing exhaustion.

I cannot see any convincing evidence that nuclear power is, *per se,* inevitably and irredeemably evil. It is perfectly possible to control it, tame it, store it, and use it beneficially. And we should all realize that 10 per cent of our UK electricity supply is already generated in this way – with no nuclear industrial fatalities but with the probable saving of many lives otherwise lost in mining the equivalent quantity of coal, or by exposure to the sulphur dioxide released in burning that coal in power stations.

It is indeed a sobering thought, that a large part of the world's plutonium (estimated in 1977 as about 100 tons) and some of the naturally occurring uranium 235 are now stock-piled as nuclear weapons in the armouries of at least five countries. The nuclear sword has been hanging over our complex civilisation for three decades. I am not competent to assess what the effect of this threat has been. In the early days of CND we heard the slogan 'Ban the Bomb'. A perceptive theological analysis at that time was written by a senior Christian colleague of mine at Harwell, now a university professor of nuclear engineering. Writing in 1954 in the *Atomic Scientists' Journal,* G.N. Walton said, 'Can it be thought that the atomic bomb is to humanity as a whole rather like the schoolmaster's cane is to a classroom of boys? The policy is so to behave that the wretched thing is kept in its cupboard and never used... Honesty and care in diplomacy, just dealings between nations, is it not possible that these can be the fruit of the atomic bomb? Clearly the latter cannot teach such lessons of its own accord, but it does provide the incentive to learn them! '

The civil uses of nuclear power – which for 25 years have been increasing – have recently come under attack with something of the mixture of idealism, fear, libertarianism and politics which could perhaps have been said to characterise the CND in its heyday. The signatories of the *Guardian* letter are quite specific: 'We can no longer separate "atoms for peace" from "atoms for war", 'Ban the Bomb' now becomes 'world de-nuclearisation'.

The fact is that God has made this world to contain uranium and plutonium, and he has allowed (or even arranged) that 20th century history includes the knowledge of nuclear fission. We cannot hide from these facts or from this knowledge. It would of course, be theoretically possible for the human race to retain the knowledge of nuclear power, but to renounce any practical use of it, for good or ill. But the moment for such a hypothetical and unlikely decision would have been in 1939, when the first scientific publications on nuclear fission appeared. In 1977, we live in a nuclear world.

If we grant that 'the fearful knowledge' is now widespread, that Pandora's box is open, or that the divine schoolmaster has now conspicuously placed his cane in the cupboard, the relevant question remains – how can we adapt to this fact? This is where questions of non-proliferation treaties, chemical reprocessing, fast breeder reactors, and alternative energy sources, are perfectly proper questions for Christians and others to debate, as are other political and social issues. As biblical Christians, we need to be perceptive and to stimulate a wider biblical discussion.

Demythologising Nuclear Energy

The New Testament 'de-mythologises' and 'de-mystifies' the 'principalities and powers', making them subject to the wisdom of God 'through the church' (Ephesians 3.10). There is a danger in current popular writing of adding unnecessary sensation to the nuclear debate. The element plutonium, for instance, has been referred to as 'the infernal element' by the BCC, or 'deadly' in a pamphlet by the anti-nuclear group, Half Life. In fact, plutonium is a metal, looking rather like lead, but even heavier. It does not levitate, bend spoons, or chase naughty children! Left to itself, a lump of plutonium can be wrapped in a polythene bag and held safely in the hand (safe enough for the Duke of Edinburgh during a Royal tour of Harwell I witnessed in the 1950s).

Two contingencies *are* highly dangerous – one is to breathe in, or swallow, or introduce through, say, a cut, into the blood stream, as little as a millionth of a gram of this element (just as a similar amount of radium would be dangerous). The other is to attempt to bring near together two or more pieces of plutonium so that their combined mass would exceed a few kilogrammes. That would cause a nuclear explosion.

But let us be quite clear – there is no need to introduce plutonium into people's bloodstream, any more than there is to inject strychnine or cyanide or any other poison. There is also no need to smash bare pieces of plutonium together, any more than one would play with chemical detonators or with other sensitive chemicals such as nitrogen trichloride. We read that plutonium has a very long 'half life' so that 50 per cent of it still remains after 24,000 years. But many chemical poisons, including mercury, lead, chlorine, cyanide and asbestos have an infinitely long half life.

All this is not to make light of the very real demands of safety and security in handling dangerous industrial substances – especially radioactive (and/or fissionable) ones. But plutonium is not something malevolent and perverse, independently seeking to destroy us. It is the God given chemical element number 94.

A similar job of de-mystification is needed with regard to the long-lived fission product and actinide wastes produced in nuclear reactors and concentrated in reprocessing plants into acid solutions or (it is hoped, ultimately) into glassy

solids. Again, the wastes do not jump out and bite people, nor spirit them away in flying saucers. They do need to be stored beneath several feet of water or behind several yards of earth or concrete, to shield the penetrating radiation, and must not be carelessly dispersed into the atmosphere or into food or water supplies. Otherwise, they are not in principle new to this planet, which has always been bombarded with radiation from the sun and also has always contained vast but well dispersed quantities of 'naturally occurring' radioactive substances.

Alternative technologies, notably sun, wind and wave power, are suggested to be capable of taking over from fossil fuels by the end of this century, without the need for nuclear power. It is stated that at present the expenditure of vast sums of money on a nuclear programme – which owes much to its military origins – inhibits the full scale development of these other possibly less risky technologies. 'If sunbeams were weapons of war, solar power would already have been fully developed', Sir George Porter, Director of the Royal Institution, London, has said.

The fact remains that, whatever one thinks about the UK nuclear weapons programme, it has left us with a valuable store of nuclear know-how, a stock of plutonium and of depleted uranium, and an enormous investment in nuclear plant and research and development facilities, plus several fully commercial scale nuclear power stations. Are we to regard all these assets as in some way tainted and so campaign to 'de-nuclearize' them? Or does it not make sound common sense and good theology to *beat their swords into ploughshares?*

The full-scale implementation of alternative technologies is at present uncertain and must wait upon the patient laboratory and pilot plant development work which is currently proceeding in the UK and elsewhere, and which appears to be adequately funded. And it is perfectly possible that if and when the giant windmachines punctuate our landscape, and hundreds of miles of wave energy platforms ring our coasts, that our descendants will then find that these alternative technologies also pose risks to life, impair the environment, and presuppose a highly sophisticated technology and a society that is able to maintain a necessary minimum of law and order. Christians ought not, I suggest, to discard nuclear technology too lightly and to trip away to worship at the primitive shrines of the wind, the sun and the waves. Rather let us de-mythologise our utterances about technology and then consider all sources of energy only on their merits.

The question of fast breeder reactors is a case in point. Any civil nuclear power programme which restricts itself to consuming as nuclear fuel *only* the minor uranium isotope 235 (this is substantially what happens in present stations) is neglecting to use the far greater store of energy which is present in the major isotope 238, also the equally abundant (or possibly even more abundant) thorium isotope 232. This potentially useful energy can only be tapped by using a source of neutrons to convert uranium 238 to plutonium 239, or to convert thorium 232 to uranium 233. The world's stocks of relatively useless uranium 238 and of thorium 232 together are of the order of two or three hundred times that of the presently usable uranium 235. Incidentally, the UKAEA holds stocks of 'depleted' uranium, already paid for and used once in nuclear reactors, which if used in a successful programme of breeder reactors would become equivalent to all of the known UK coal reserves! That would introduce us to a so-called 'plutonium economy'. To a degree, this conversion of uranium to plutonium is already happening, and has been for the last third of a century, in every nuclear reactor, in an increasing number of countries.

This bountiful energy treasure is not simply ours for the taking, because the full technology required is at present incomplete, although demonstrated on a smaller scale. The most likely technology at present seems to be the use of the neutrons generated by a nuclear reactor, to transmute a so-called 'blanket' of uranium 238 into plutonium, or of thorium into uranium 233. The new nuclear fuel is then separated chemically and is eventually used to fuel further reactors. It is to develop this technology for up-grading uranium that the UK and several other countries are building 'fast breeder reactors'.

Not as much attention has yet been paid to the use of thorium, though this is theoretically possible as a blanket in the fast breeder. Also, not as much attention has been paid to the use of heavy water moderated thermal reactors of the Canadian pattern, for upgrading thorium or depleted uranium. Again, some de-mythologising is probably required – and the nuclear physicists own jargon has not been helpful. The technology is not 'breeding' – even metaphorically – after any recognisable biological pattern, but the 'conversion' of one nuclear species to another.

It could understandably be objected that the precaution required by the nuclear power industry, in handling nuclear reactors, plutonium, and the fission products, are so exacting that the game is not worth the candle. That must be an industrial, economic, social and ultimately a political decision. Christians will in various ways add their voices to the debate and can and should attempt to have a part as citizens in the decision-making. It is not obvious, however, that all the theological considerations point in one direction, as seems to be suggested by those Christians who would emphasise the possible loss of personal freedom, approaching even the establishment of a 'police state', which they say might be necessary to thwart the possible clandestine diversion of plutonium to criminal ends, or the possibility of industrial action by key nuclear employees.

'What kind of society do we want?' asked the Archbishop of Canterbury. Not a police state, certainly. But neither do I personally want a state of such libertarianism, permissiveness and anarchy that either terrorist groups, or politically extreme groups of workers, could blackmail our political and industrial decisions, including those of a civil nuclear power industry. Law and order may not be the greatest gift of Christianity, but they are surely consistent with the gospel.

More speculatively and controversially I would ask if it is part of God's providence in history that humanity is being brought face to face, in civil life as in war, with the horrible consequences that could follow selfishness, anarchy and ill-considered violence in a nuclear world? It may well be that we will show ourselves to be too sinful a civilisation to be entrusted with the knowledge of nuclear power – and to say that is perhaps also to say that we are obviously and in an unprecedented way experiencing the terrible judgement of God, not for discovering nuclear fission, but for being ill-prepared when by his providence it came. I cannot imagine that the threat of divine judgement will be lifted by our continuing in indulgent and ill-disciplined ways, personally, nationally and internationally, and at the same time crying 'Ban the Bomb' and 'World de-nuclearisation'. That I would regard as a liberal humanist delusion.

Is it not possible for Christians and nuclear technologists (many of whom themselves are active Christians) to support a third way of cautious sober nuclear development, rather than either extreme of brash 'scientism' or de-nuclearisation?

IV. FOR A MORATORIUM - A FRENCH VIEWPOINT*

ROGER MEHL

An unusual cartel is in process of being formed to defend nuclear energy. It includes the President of the Republic, the Government, the majority in Parliament, the Electricité de France, the CGT (Confédération Générale de Travail) (French Trade Union Congress) and the Communist Party. The CFDT (Confédération Française du Travail) and the Socialist Party who include in their membership fervent ecologists are more reserved.

Why this cartel? Because following numerous incidents and nuclear accidents public opinion is more and more uneasy about nuclear power stations. The ecological movements are clearly gaining ground. The building of each nuclear power station will face a more and more determined resistance and the occupation of the site; and the Government is quite helpless faced with this kind of opposition, especially when it is non-violent.

In spite of the justifications and the good conscience proclaimed by the public authorities, it is doubtful whether the Government can again resort to the method used at Creys-Malville. It is certain on the other hand that the ecological and anti-nuclear movements, having learnt from experience will organize more carefully the control of their supporters and will take care not to be overwhelmed by suspect elements who are only interested in provoking violent confrontations.

The argument of the different members of the cartel is simple. It is strictly economic. At a time when the provision of energy becomes uncertain, when the traditional sources of energy are being exhausted, France cannot allow itself to disdain nuclear fission, an inexhaustible source of energy. It would be irresponsible on the part of the Government not to be anxious about the end of this millenium which threatens to be harsh.

The argument would have even more force if it also took account of the energy needs of the Third World. But we know that in France and throughout the West this kind of argument has no appeal. The concern here is limited to France. President Giscard d'Estaing affirms with assurance that the development of nuclear reactors, the establishing of new nuclear centres, are a clear necessity, which all sensible men should recognize. In its recent report on this question the World Council of Churches itself argues that an absolute abandonment of nuclear energy is unthinkable. But it then expresses some reservations which the President of the French Republic seems not to share.

It is not that he ignores the unease of the French people. But he assures us that the problem of security has been resolved, that instructions have been given to strengthen the systems of security and that therefore we can go on vacation without any worry.

Here lies a serious weakness in the argument. Is it enough to give instructions as strong as they may be, and to ensure their rigorous application in order that the security problem may be resolved?

We do not doubt either the good faith of those who govern us nor the scientific and technical competence of the nuclear engineers. The difficulty arises elsewhere: we have not come to the point where we can pretend to have mastered fully nuclear technology. This is true in relation to the classical nuclear reactors where various accidents and breakdowns which have occurred in recent years amply prove our inefficient mastery to which must be added the problems which up to this point have not been resolved: elimination of a rapid and catastrophic rise in the temperature of the cooling water, and uncontrollable modifications in the climate.

Now without having resolved any of these problems we have decided to take a new step, the construction of a breeder reactor, audaciously named Super Phénix, in order to produce plutonium.

Numerous scientists, not all it is true, have said again and again that we are engaging in a risky venture. The president of the U.S.A. has decided to suspend the construction of breeders and to campaign against their construction all over the world. In the Federal Republic of Germany they begin to speak of an atomic moratorium. Even those who like myself, have no scientific expertise in this area, cannot fail to take seriously the warnings.

No doubt it will be argued that all great technological discoveries have always brought risks, that these risks have been gradually eliminated, that this is the price of progress, that nothing is gained by waiting and that accidents themselves help to increase our knowledge and contribute a greater competence. It is true that the first canons often exploded and killed their gunners, while that hardly ever happens with modern artillery. It is true that the first modern surgeons often killed their patients in applying techniques that they badly understood and that their failures sometimes showed the way to safer techniques.

Although the death of a man is always an infinitely grave thing let us accept this kind of reasoning. But let us add immediately that there is a question of scale: imagine that the Super Phénix explodes, or that a serious leak occurs. Thousands or even hundreds of thousands of people would die. We are no longer in the time when badly mastered technological discoveries threatened only a few individuals. A new product such as a food or drug or others immediately affects millions of human beings. Nuclear fission more than any other discovery is capable of affecting whole populations.

Because of this change in scale we must develop an ethic or morality for the techno-nuclear era. And this morality cannot be the implicit morality that technology only develops. This morality is very simple. It is expressed in the following axiom: we must immediately do all that is technically possible. An example: the discovery of contraceptive pills. Certainly they were tested many times

*) Published in *Réforme*, August 13 and 20, 1977

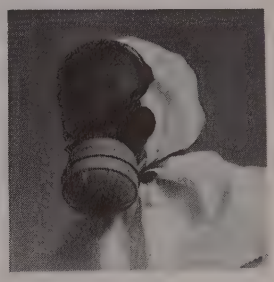
before being placed on the market. Nevertheless that did not prevent some of them, which were not as innocuous as had been thought, from being withdrawn from the market after several years.

We need another morality. Its fundamental axiom appears to be this: to know how to wait. We must rediscover the old Christian virtue of patience. Do not think that this applies uniquely to relations between people. It must also be applied to the use we make of our own discoveries. Biologists and doctors have already learnt, even in urgent cases, like the treatment of cancer, to wait patiently until tests have been carried out over a long period before they recommend a particular new technique or medicine.

Contrary to what certain ecologists think there is no *a priori* reason to renounce the use of nuclear energy. But it is necessary to limit ourselves to a small number of approved nuclear reactors of a limited capacity which will be less factories for production than laboratories aimed at increasing our mastery of the technology. It may be that this period of research under conditions of minimum risk may be long and that as a result we may be obliged to live a little more austerely in the coming decades.

The morality of knowing how to wait (savoir attendre) is today the only way of fulfilling our responsibilities to the generations to come. François Mitterand is a thousand times right to ask for a referendum on nuclear energy. Because such a procedure carried out fairly would help to convince the majority of the French that the actual state of our technological knowledge requires a nuclear moratorium.

V. REPORT FROM A CHRISTIAN STUDY GROUP IN THE FEDERAL REPUBLIC OF GERMANY ON "ALTERNATIVE POSSIBILITIES FOR ENERGY POLICY" *



FRIEDHELM SOLMS AND WOLFGANG LIENEMANN

A. The Energy Debate in Germany

Friedhelm Solms

Not since the discussion about the re-armament of the Federal Republic of Germany has any subject been argued about in this country with so much emotion and commitment – and also with so much false pathos, the help of so much power, money and prestige – as the energy issue. This clearly so much surprised those we call policy-makers in politics and industry that they tried to play it down or dismiss it it by a mixture of threats and scaremongering ("the lights will go out in 1985"). Surprisingly and perhaps because of the dogged way the debate has been carried on by all sides, the general aspects of the energy problem are gradually beginning to emerge. This is important since energy is a key problem of all industrial societies.

The political discussion on energy in the Federal Republic of Germany has now entered a decisive phase, one reason for this being that time is running out for the politicians. The political parties are preparing their annual party conference where the energy issue will play a leading role. After a long period of abstinence the parliament has debated the government's "basic ideas and basic figures" on energy, which will in late 1977 form the basis of a new energy programme. This programme has been expected for a long time, and postponed again and again. Although framed with a view towards medium-term energy perspectives, politically the fate of the new energy programme will depend solely on the central question: the nuclear issue. This question divides all social groups and all political parties into supporters and opponents.

Each group only considers those aspects and arguments of this complex problem which strengthen its own position. Even the scientific community has surprised people. The almost unlimited credibility stemming from the disinterested objectivity once attributed to its members has begun to wane, a fact which they themselves have hardly registered or reflected upon. Today there are supporters and opponents of nuclear energy in all fields of science. Both groups assure the public that they have sound arguments to support their point of view, although the supporters seem to have a broader audience. But both groups often overlook the fact that even scientific judgements are influenced by historical, social, geographical, and biographical factors. There is no such thing as abstract objectivity floating in a historical vacuum, independent of historical processes and the forces of society. Today this has had to be realized anew by scientists. We may even say that the sharp confrontation in the public discussion is just a reflection of this unenlightened situation. And generally the claim to absolute truth of nearly all of the statements is also an expression of this uncertainty.

When the Evangelische Landeskirche in Baden approached the FEST at the end of 1975 with a request for a scientific report on the whole energy problem, it could not, at least at that time, have been foreseen that the publication of this report would coincide with a political situation characterized by: a seemingly insurmountable polarization of society; growing doubts as to the independence of scientific judgement; and an inescapable necessity for politicians to reach a decision. The request by the Evangelische Landeskirche in Baden was, however, a sign that the churches could no longer remain aloof in the public discussion of the energy

* This article and the next one are introductions and summaries of a research report of FEST (Protestant Institute for Social Research) (Heidelberg, FRG) on the energy problem. The report has the German title *Alternative Möglichkeiten für die Energiepolitik.* It is published by and available by request at "Forschungsstätte der Evangelischen Studiengemeinschaft, Schmeilweg 5, D-6900 Heidelberg". The authors of the articles are members of the project team.

question even if they wanted to. As in many other Landeskirchen today, many members of the congregations in Baden, including pastors, have resolutely taken sides with the citizens' action groups protesting against the planned nuclear power plant at Wyhl with a sense of Christian responsibility. What started as a local dispute with local authorities has, however, as a result of a wrong assessment of the situation, careless remarks and unnecessarily harsh reactions by politicians, developed into a broad public dispute which was almost certainly not intended or desired by either side. Today even top government leaders have to admit that the conflict at Wyhl is not an isolated case which they can ignore.

The report carried out at the suggestion of the Landeskirche Baden was seen by FEST as part of its statutory task to "help the churches in their dealing with the world". It was given the opportunity and the responsibility of making use of its independent status as a research institute as guaranteed by its church sponsorship, to make clear the real connection between all the questions tied up with the energy problem, thus seeking to end the one-sided and arbitrary separation of particular arguments. The extent of the interdisciplinary and integrated research work demanded by the complex structure of the energy problem, however, exceeded the capacity of the FEST research team. In addition to the special knowledge and competence of the FEST staff, it was therefore necessary to employ the continuous help of outside experts. Fortunately the project organizers could rely on institutes and institutions with which FEST has had working contacts for years. It was thus possible to form a team of 25 research people, working about 15 months on the scientific basis of the report, which was eventually written by the four members of the project leadership. Furthermore it was necessary to hold consultations on key issues of the energy problem with a number of experts representing different fields of research, management and administration. The function of these consultations was to make a critical examination of what was scientifically proved and what was still controversial even among experts.

Unlike a large number of scientific appraisals dealing with specific aspects of the energy problem, the FEST report provides an integrated analysis of the scientific, technical, economic, social, legal, military and foreign policy aspects of the energy problem and does not confine itself to a critical examination of the problem of nuclear energy. This critical analysis of the present energy policy in West Germany forms the first part of the report. It concludes that the official energy policy cannot reach its own goals even by a rapid expansion in the use of nuclear power. Moreover the planned employment of nuclear reactors on a large scale causes additional problems, which up till now have hardly been discussed with all their implications. Some of these are: sabotage and terrorism, the serious consequences for military defence, as well as difficulties in foreign policy resulting from the growing difficulty in distinguishing between peaceful and military uses of fissionable material. The report therefore concludes that it is becoming more and more doubtful whether the present policy can be justified and points to the need to look for alternatives.

The possibilities of an alternative energy policy are outlined in the second part of the report and examined for their implications. These show a range of possible options for political decision. Based on the results of the analyses of the first part, reasons and arguments are presented to prove the feasibility of these options. Thus, the thesis of the report, that the energy problem which on the surface is understood only as a political matter, actually concerns fundamental principles of our existence, and is thus a subject on which the Church cannot remain neutral. The report therefore argues that new priorities must be devised, to replace the criteria of the official energy policy based primarily on economic considerations.

In this context the Christian responsibility for the whole of mankind has to be considered in a twofold sense. Taking seriously the Christian commandment for charity, a Christian, involved as a citizen in the public discussions and deeply concerned about the contemporary decisions on energy policy, cannot ignore the emerging global responsibility facing the ecumenical community of all Christians. Charity may not be restricted regionally to the members of one nation or one area, nor to the members of those generations living at the present time. This discernment leads to criteria and priorities completely different from those which politicians use today in discussions and in policy-making on energy and which are based on short-term advantages.

A second point is that while insisting that the fundamental message of the report is based on Christian and Church responsibility, the practical implications of the report have to be formulated in such a way that consensus on them can be reached beyond the limits of Christian denominations. Then and then only will they have a meaning which the public will understand as they seek to introduce these ideas into the opinion forming process of society. In the report we seek to put the problem of energy in a useful and clarifying relation to the basic views of theological ethics and Christian understanding of creation and humanity. Such theological perspectives are, however, not identical with the basic views of the report, nor are they confined to them. The report does not attempt to provide final answers, nor does it aim at drawing up a complete political programme to solve the entire energy problem. Its main intention is rather to enable the reader to form his own independent and relevant opinion.

B. Planning Self-Limitation

Wolfgang Lienemann

The report by the "Forschungsstätte der Evangelischen Studiengemeinschaft" on *Alternative Possibilities for Energy Policy* is based on a few very simple ideas which must be explained if the central thesis of the report – the necessity of a fundamental revision of the energy policy of the Federal Republic of Germany – is to be understood.

Anyone can appreciate that the resources of a relatively limited system such as the earth are not infinite. Max Weber knew some day "the last hundredweight of fossil fuel will have been burned up". The more growth rates of industrial production and the consumption of non-renewable kinds of energy increase, the sooner the day will come when reserves will start to come to an end. These reserves have been formed in the course of millions of years of the earth's history; the privileged nations, particularly those in the Northern hemisphere, are undoubtedly able and likely to use them up in less than maybe 300 years, the life time of a good ten generations. This historically unique wastage process, supported by political power which is at the same time also dependent on it, cannot be carried on indefinitely. This we know today but there is yet no sign of any great change in the attitudes of politicians or in the measures taken. The great coalition of parties, employers' associations and trade unions seems not to be aware of alternatives to growth which will make the inevitable awareness of the illusions of belief in growth all the more painful. But if one generation chooses to keep its eyes closed, their grand-children will have to suffer the consequences of their mistakes.

Moreover, with the inevitability of a law of nature, a growing use of fossil and nuclear energy cannot help but result in an ever-increasing heat-pollution, because all kinds of

energy usage produce heat. Each power station gives off heat into the rivers and the atmosphere. Energy growth means a constant increase of thermal pollution, affecting ecosystems and the whole environment. Global shifts in climate are probable which those children born today will experience if present rates of growth are allowed to continue. No law to protect the environment can prevent this increase in heat, unless the growth rates of energy consumption can be lowered, first gradually, then drastically in the medium and long run.

So two limits become apparent: a limit to natural resources and a limit to the burden which can be put on our natural environment. No one can define these ecological limits precisely, but no one can deny they exist either. At all events they are within range of being affected by today's energy planning. So we are faced with the simple alternative: either we wait until we are confronted with these limits, or we try to avoid coming up against them, or infringing on them, in time. Since these limits do exist, the second possibility seems more sensible if we want to plan for the future and not leave everything to chance (which would not be very sensible). If we believe the possibility of slowing down growth rates of energy consumption before such ecological limits are reached, to be sensible and realizable step by step, the question is, should we not start on this as soon as possible, especially if this step is going to prove inevitable at a later stage anyway.

In addition to natural limits each society also has its social limits. Just because a thing is technically possible, promises to bring progress, and may even claim to be economical, does not mean that it is necessarily socially realizable. It may be technically possible to build 100-200 nuclear power stations in the Federal Republic of Germany along with the necessary plants for reprocessing and waste management; technically it may also appear to be no problem to handle plutonium in tons. Of course this requires safeguarding society by political, legal, technical and physical precautions. The question arises whether the danger of a misuse of plutonium does not necessitate safeguards for production, transportation and storage with a degree of accuracy which may be unattainable.

And then the next question must be whether society can be expected to handle such problems resulting from such a large-scale technical structure and whether they would be accepted by the public.

Up to now there has been little evidence of this. Citizens' protest movements everywhere seem to indicate that technical developments in the Federal Republic are gradually coming up against limits as to what is socially acceptable. The controversial problems concerning the building of new power stations (and by no means only nuclear power plants) are only the most drastic example of a more general difficulty, i.e. that the relation between large-scale technical structures and our social-life-world becomes more and more confusing. It is then only a short step from fear to aggression, or even to political apathy. The problem of nuclear power plants is special in that the plant itself becomes, as it were, a manifest symbol of an otherwise highly abstract and obscure matter. That it is abstract and obscure is due to the introduction of more and more complex, large-scale technical systems, which differ qualitatively from earlier stages of technical development. Earlier technical developments could still – right into the 20th century – be more or less understood as technical means in the form of tool-like improvements, or as complementing and supplementing human skills; but modern techniques, in particular in the field of extracting raw materials and producing energy, are already different in that thay change man's natural and social environment irreversibly. In addition, the individual citizen is becoming more and more dependent on facilities installed for, and necessary for, the whole of society. So it is becoming increasingly difficult for him to live his own life relatively independent of all this. Increasingly he feels powerless and more and more loses his sense of direction. For no individual responsibility is possible for structures which one cannot understand. Moreover, large-scale technical systems require long-term, far-reaching planning, which threatens to remove completely the little local and regional political autonomy still left today.

The citizens' action groups which have sprung up in the last few years are also a sign of protest against such large-scale technical developments. Many people cannot see any concrete value in such developments beyond an abstract increase in productivity. It is possible that this protest-potential will simply disintegrate, the more so in view of growing unemployment; but it is also possible that the cry for more attention to be paid to whether technical developments are acceptable to society will become even louder. Up to now the protests, especially those against nuclear energy, make the second possibility seem more likely. They are a signal that even if a continuation of the present energy policy were *technically* possible, the *political* price to pay for it could be too high. A policy cannot be pursued indefinitely against the opposition of the majority or a significant minority of the population. The existence of social limits to today's energy policy can no longer be denied.

There is one further limit to energy growth rates proceeding along these lines; this is not so much a *technical* limit caused by the growing strain put on our environment, nor is it a *social* limit caused by the growing strain on our society. It is a *moral* limit which is infringed when we cease to be concerned about future generations. All raw materials and energy consumed by privileged nations today are consumed at the expense of future generations, in particular those just born or not yet born in the Third World.

We should no longer shirk asking what can be done to avoid infringing the technical, social and moral limits to an energy policy aimed at continuous growth. The FEST report is convinced that this question compels us to investigate and develop systematically all realizable possibilities for limiting further growth of energy consumption. The existence of the limits forces us to look for alternatives; the only question is whether we shall be sensible and anticipate this necessity or whether we prefer to wait until the necessity is upon us. Today the only known long-term alternative to consuming non-renewable kinds of energy is the systematic development of the use of solar energy. If solar energy were used for heating purposes, which is what a large proportion of all energy is used for, it would already today be possible to reduce the growth in consumption of other kinds of energy. In the long run it is also technically possible to obtain high temperatures and electricity with solar energy,e.g. by producing hydrogen. This has its price and also requires an extreme economic effort. But if we are not willing to face up to this effort today, the problems we thereby put off tackling could become more and more difficult to solve.

To plan now to meet the necessity of self-limitation is thus unavoidable. Given the political conditions of modern industrial society this is undoubtedly an extremely complicated process. It is imperative not to trigger off *more* social crises than the continuation of present energy policy will in all probability call forth. For this reason, FEST suggests combining two energy planning strategies. *Firstly*, energy growth rates should be slowed down immediately. This requires a large number of laws, regulations and measures. Above all it requires a political will and a public able to influence this will. It can be shown that energy saving

measures do not necessarily have to restrict the use the consumer makes of energy, if all saving potentials are systematically taken advantage of. Nor does it necessarily mean endangering jobs. *Secondly,* however, it is necessary today to continue systematically developing those sources of energy which are renewable, especially solar energy, by setting priorities in research. Technically the possibilities are known, but they cannot be of use economically until politicians can make up their minds to pay a political price for renewable energy, as they have done up to now with all other kinds of energy.

Planning self-limitations does not mean "back to nature". It would be unrealistic not to mention the many dangers, some of them unknown, which could crop up along the way. But the dangers we know to exist as far as the present energy policy is concerned leave us no choice but to look for alternatives. Yet there is no use in discovering them, explaining them and determining all their practical aspects, as long as politicians refuse to think about and as as long the public does not oblige the politicians to think about them. This is probably not the least important of the churches' tasks.

VI. NUCLEAR WASTE MANAGEMENT

P.J. DYNE

This talk divides into three parts:

1) Nuclear wastes; what they are and what is the concern.
2) Geologic disposal; what has to be done.
3) Nuclear wastes; in the context of public perceptions, responsibilities to future generations and other environmental effects.

Nuclear wastes; what they are and what is the concern

The nuclear fission process in a reactor produces new atoms. The uranium atom, when it breaks into two parts releasing energy, leaves behind two smaller atoms called "fission fragments". We also speak of these atoms as "fission products". Some of these fission products are radioactive. As the fission products have no value they are termed "radioactive wastes".

At the same time, new atoms heavier than uranium are formed, plutonium being the best known. Americium and curium are two others. Collectively these heavy elements are called actinides. They are also radioactive. Plutonium is, like U-235 itself, fissionable and so it is an energy resource. Since it has potential value it can't be called a 'waste'.

All these waste products are formed in the fuel – the ceramic uranium dioxide which forms the meat of the fuel bundle. Only a small fraction of the uranium atoms is changed. The mass of new materials in the spent fuel is about 1% of the uranium. Since many of the world commercial uranium deposits contain about 0.1% uranium in the mined ore, the mass of new materials is near to 1/100,000th of mined ore. These new atoms are embedded in the fuel material. The fuel bundle itself is unchanged in form and appearance when it emerges from the reactor.

Radioactive materials are, as you all very well know, hazardous materials – they are carcinogenic. We are concerned over the possibility, due to mismanagement or any other circumstances, of small amounts of these materials entering the air we breathe or the water we drink. Some of this material could then become incorporated into our bodies and could then cause cancer. Thus, the objective of "waste management" is *'Isolation from the Environment'.*

Radioactive materials decay with time. For fission products they decay away so that roughly 1/1000th of activity is left after 300 years. For plutonium – the dominant actinide, the decay is much slower – the time to decay to 1/1000th is about 250,000 years. It's interesting to plot the amount of activity as a function of time. (Figure 1) Very large amounts of activity due to fission products decay within 300 years; a much smaller amount of activity due to plutonium decays over a very much longer time. The extent of the potential hazard is roughly proportional to the 'amount of activity'.

I am going to concentrate on the ultimate disposal of wastes, putting to one side the storage of spent fuel. I am also going to assume that, at some time in the future – twenty years hence – fuel will be reprocessed. (I realize that this is a matter of some controversy, but I feel that this is best dealt with in the question period.) When this is done we will have two products – enriched fuel containing plutonium which is returned to the reactor – the plutonium then being destroyed – and separated fission products. I should emphasize that reprocessing does not really make any difference to the need for isolation of plutonium and other actinides in the long term. Chemical separation cannot be perfect so there will always be some residues of plutonium and other actinides. The wedge at the bottom of the Figure 1 will be even smaller, perhaps 1/10th of the size I showed – but it is still there and we must plan accordingly.

This time scale for decisions on reprocessing is one of the difficulties in explaining the waste management in the public domain. Because it is probably twenty years or more before reprocessed wastes would be available for disposal one can't expect to be disposing of material now. Nevertheless the time for development work and planning in building demonstration repositories is *now.*

Geologic disposal; what has to be done

There is now an international consensus on long term waste disposal – namely that reprocessing wastes be solidified and put into insoluble form as glass blocks – and that these blocks be put away in dry stable rocks. If a

decision were taken never to reprocess fuel then the fuel would be similarly disposed. I must emphasize here that the key requirement is isolation from water, since that is the pathway by which radioactive material could enter the environment. For extra safety, we propose to put water-proof materials away in a water-proof box.

The geologic box is rock formation which is as old, stable, dry and impermeable as we can find. The age and stability certify that for periods in the past – times very much longer than a quarter of a million years – the structure has been stable. It is therefore unlikely, in the future, to be the scene of new violent geologic processes. Every mineral ore body is a natural demonstration of geologic isolation of this sort. What is being proposed is that we mimic nature's isolation, making an artificial ore body. The figure on p.49 illustrates the time scales.

You can regard this Figure as the result of a mechanical test procedure. The rocks we see today bear the record of all the past geologic events, earthquakes, ice ages and so forth, which nature has been able to inflict on them over geologic time. From the nature of things then, old stable rocks are in areas where active geologic forces are small. Geologists can, using the principle of uniformity (see para. 399 of the Flowers report which I quote later on), have then a high degree of certainty that these forces will not have violent effects in further small increments of geologic time. They cannot, however, ever make an absolute prediction of stability.

The inherent uncertainty in geological prediction has to be met head on. It is here that the insoluble form of the matrix used to contain the material comes into the argument. As I've said, radioactive materials can be cast into glass materials in the form of blocks. Some 15 years ago, in what is now a classic experiment, several such blocks were made at CRNL in an experimental demonstration and put into shallow burial in contact with ground water. In a purely technical sense it can be argued that this procedure alone provides enough isolation since the water leaving the blocks is still potable – the radionuclide concentrations being below the maximum allowable for drinking water.

Over and above the insolubility of the material there are two further barriers, one the slow rate of movement of deep ground water which may give hundreds of years delay, and further the strong retention of soluble cations (metals in solutions) by soils and clays which gives many thousands years of delay. There are thus 4 impedences to the release of radioactivity (4 layers to the box!) to the environment.

1. Geologic stability
2. Insolubility of wastes
3. Slow ground water movement
4. Retention of cations (metals in solution)

While we now know that the impedences given by each of these layers are very large, there are several detailed technical matters still to be resolved before we can be sure that we have the best possible system. I should emphasize that they are *not* questions of form, not "Can we build a bridge across this river?" but rather "Should we build a steel or reinforced concrete bridge?" or "Should it be a suspension bridge or a cantilevered structure?"

Some of the matters which I view as important are:

1) The response of the mined cavity to heat release. Heat released by radioactive wastes will cause thermal and mechanical stresses and possibly local fractures of the cavity. How closely can we pack wastes together without causing difficulties in operating and maintaining the cavity?
2) The permeability of natural fractures as a function of depth. At what depths might cavities become 'self sealing'? There is indirect evidence that something like this occurs at depths of about 2000 feet and below. It is however a new concept for geophysicists; when better defined it will provide a most valuable design parameter for selecting sites and building repositories.
3) The large scale production technology for vitrifying wastes and the study of long term effects on the leachability of materials from glass. Much work in these areas is underway.
4) The study of ground water movements at depth. These have to be done at specific sites since general information is only useful conceptually. In this connection it is important that a number of sites are studied.
5) Further studies of the retention of cations (metal ions in solution in water) by soil and rock. One of the interesting observations from the CRNL work is that plutonium is very strongly absorbed by sand. We have to know the extent to which this is a general phenomenon.

While I have suggested to you that long term waste management is not, in any way, an overwhelming technical problem, I don't want you to underestimate the care and attention to detail required in selecting and developing a site for geologic disposal of wastes. The Atomic Energy Control Board will, I am sure, be very sceptical and critical of the details of these developments and will insist that emplacement be, initially, only done on a retrievable basis. If I were a member of the Board I would be equally insistent and determined on these matters.

The time to develop a site is now. The detailed studies of possible sites and the mining and excavation will take several years. The experimental work required for both experimental and operating licenses will itself take a further several years. The apparently long lead time of twenty years or so, in fact, is quite short.

In summary of the more technical part of this talk I will cite two "independent" studies on nuclear energy and its implications: the U.K. report of the Royal Commission on Environmental Pollution (the "Flowers" report) and the Ford Foundation study "Nuclear Power, Issues, Choices". Before making these specific quotes I should add that I do not have any difficulties with the Waste Management sections of either of these reports. The point of view I am expressing is in essence consistent with the general thrust of their comments. From the Ford Foundation Study, p. 245:

> "We believe that nuclear wastes can be disposed of permanently in geological formations in such a way that there is very little prospect of material escaping into the environment. Moreover, even unlikely failures of repositories in the distant future would not have large consequences to human populations. This is true independent of whether the wastes disposed of are spent fuel or the resolidified and transuranic wastes left after reprocessing and recycle. We are more concerned about the potential hazards of wastes before they are sequestered in geological formations. Experience with waste management is not encouraging. There has been a recurrent substitution of short-for-long term goals with less than adequate management practices. These include neutralization of acidic reprocessing wastes, leaks from single-walled tanks containing liquid wastes, and shallow land burial of transuranic wastes. Management of nuclear wastes as spent fuel presents fewer opportunities for failure than does a fuel cycle in which reprocessing occurs. We believe that most spent fuel should be stored retrievably in the same geological formations which would be suitable for permanent disposal, until decisions can be made on plutonium breeders."

In a discussion of the factors of safety in geologic disposal, estimates of the probability and effects of failure ("calculations of this type"), they add (p. 262):

> "While calculations of this type obviously cannot

anticipate all possibilities, it appears to be very difficult to postulate realistic failure mechanisms which would imply consequences of catastrophic, or even serious, proportions to future generations. Additional studies of such failure mechanisms are not only essential to testing this conclusion but would also assist in selecting repositories and insuring against failure. We believe that the probabilities and consequences of failures of waste repositories are very small for properly chosen repositories and that this will be substantiated by the detailed site-specific studies necessary to make such choices. Since the present rate of generation of waste will no more than double the magnitude of our current waste problem over the next five to ten years, there is time to conduct such studies without increasing the ultimate risk appreciably over what it already might be. However, our interest in the waste problem extends beyond optimism about technical feasibility. There are important questions about the abilities of institutions and individuals to recognize and fulfil responsibilities for implementing successful management and disposal practices."

The Flowers report says (p. 397):

"We have concluded that there are essentially two reasonable options for the permanent disposal of high level vitrified waste, namely geologic formations on land and below the ocean floor in stable areas. Although we are not ourselves able to judge at this stage whether either of these options would be safe, we were sufficiently persuaded by the arguments advanced by IGS and the IOS, who have no commitment to the promotion of fission power and who appeared to be expressing the consensus of views among their professional peers that each offers a big enough chance of success to be worthwhile pursuing seriously. We regard the demonstration of a safe disposal means for high level wastes to be an essential prerequisite to a big expansion of nuclear power. In our judgement therefore, work should be carried out vigorously by the UK on both options, preferably in collaboration with other countries in order to assess their merits and probable relative costs. In the next two sections we shall describe the criteria that should be used to determine the programmes of work, how they should be conducted and by whom, and the organisation needed to direct and pay for the research work and the subsequent waste disposal facility".

And

"The idea of disposing of long-lived high-level radioactive wastes in a geological formation that is physically, chemically and seismically stable has been advocated since the mid-1950s when such wastes were first generated in large amounts. There is the prospect of secure isolation from man's environment for very long periods of time, subject only to the possibility of transport in circulating ground water. Geologists, working on the "principle of uniformitarianism" under which existing geological processes are keys to the past and by extrapolation, to the future as well, can have fair confidence that formations that have been stable for millions of years in the past will continue stable for periods of 100,000 years in the future. The principal uncertainties are likely to be the effect of climatic changes and alterations in sea level rather than in the solid geology."

Nuclear wastes; safety

I have only said that there are many large factors of safety in the proposed schemes. This doesn't however, really say much about whether the scheme is "safe enough". General calculations have been attempted and are described in the Ford Foundation report. I have spent a lot of time in the past four or five years trying to analyse that question. I started off by asking myself whether the proposition of nuclear wastes disposal made any sense at all. Should we even attempt it?

This analysis of safety of nuclear waste disposal is, in essence, asking the question of "how hazardous is an inventory of material *inside* a box"? "What is the hazard of a lion in a cage?" Note that the hazard of the lion and of the lion inside a cage are two entirely different things.

What is it that we are trying to contain inside the box? It would be nice if we could compare these amounts of new hazardous materials to old and familiar hazardous materials. (To compare, somehow, the hazard of a caged lion to the hazard of a caged tiger!) Such comparisons have to be thought through very carefully. For radioactive materials one has to consider the amount of activity, the type of activity, the efficiency with which it can be absorbed by the body from drinking water and the extent to which it is concentrated by the body in radiation sensitive organs. The International Commission on Radiological Protection takes all these factors into account in establishing drinking water standards for radionuclides. The allowable concentrations in drinking water are then a weighted comparison of the hazard of different radionuclides in water. From these one can compare hazards of *amounts* of different radionuclides in terms of the amounts of water needed to dilute the inventory of materials to drinking water levels. This is the method of comparison by the "required dilution in water". It is an arbitrary yardstick, and while it is probably imperfect, nobody has been able to think of a better one!

One can calculate these required dilutions for any quantity of radioactive materials; for the amount of uranium ore containing 1 kg. of uranium; for 1 kg. of uranium containing,after it has been in a reactor, fission products and plutonium; and for 1 kg. of uranium containing only actinides, after the fission products have decayed away.

If we do this for these equivalent quantities of uranium ore, and of radioactive wastes, where the fission products have decayed, the required dilutions in the long-term are of the same order of magnitude. I therefore conclude that I have no more reason to be fearful of long-lived activity from plutonium buried in geologic storage, than of activity due to radium in ore bodies still unmined and undiscovered. It is essentially for this reason that I am personally satisfied that the technical problem of disposing of wastes is not a great one and that the proposal is 'safe enough'.

Ethics and responsibility

The long time over which radioactive materials remain hazardous raises concerns over whether future generations should be burdened with the care and concern involved in managing radioactive wastes or with the potential hazards of storing them.

Turning this rhetorical question into a positive statement:

In no way should we be delegating responsibilities to future generations; our responsibility *today* is to make sure that the minimum of care and responsibility be left to our successors. Schemes of continued monitoring and surveillance for the *whole* of the hazardous life of these materials are unacceptable. To me they are nonsense. Sooner or later (it will be many decades before this will happen) the mined cavities have to be backfilled and closed up. For reasons I have already given, there should be no need for monitoring and surveillance. We should engineer it that way.

To quote again from the Ford Foundation study: "It appears to be very difficult to postulate realistic failure mechanisms which would imply catastrophic or even serious

consequences to future generations". In essence then, the schemes I have been talking about are designed to meet the ethical question.

I realize, of course, that this response may give little satisfaction to some. Here we reach the nub of the issue, which is the difference between the technical perception of the matter, the way the so-called experts see it, and the perception of the common man.

The idea of making new chemical *compounds* is accepted (we're so used to it) even if some of them are very hazardous, which they often are. New chemical elements or isotopes are however, a different matter because, radioactive or not, they are patently indestructible. They are *persistent* materials.

Besides this persistence, there is the general perception of the hazards of radioactivity and high energy radiation. In a word, radioactivity is a *'peculiar* hazard', without comparison to any other material or process. It is beyond the scope of this talk to discuss where and how this perception arises. Suffice it to say, that it exists. It is readily and frequently exploited in the press and media with quite extraordinary consequences. I am thinking of instances of people feeling that they are in danger of their lives in visiting AECL laboratories at Chalk River and Whiteshell, or being forbidden by their wives to make such visits!

We have then the combination of persistent materials, the "peculiar" hazard and the consequent need to isolate them from the environment for a very long time indeed. The requirement for long term isolation is difficult to accept, essentially, because it is a new idea. You should note, however, that this definition of the problem, as seen by the layman does not, in factual terms, differ from that of the technologists. In non-factual terms, the divergence hinges on the meaning we attach to the "peculiar" hazard of radioactive materials, which to me, is the essence of the controversy.

It is for this reason that the ethical question is posed for radioactive waste management and not in other areas where it is, in logic, equally applicable. Let me give you an example: I have about 10 grammes of mercury in the fillings of my teeth (enough to kill me about te times over or more, if it were to dissolve and get absorbed into my body). When I die I expect to be cremated. This mercury will then be dispersed to the environment. Because mercury is not radioactive this environmental insult is for all eternity – with a corresponding potential of care and concern for all future generations.

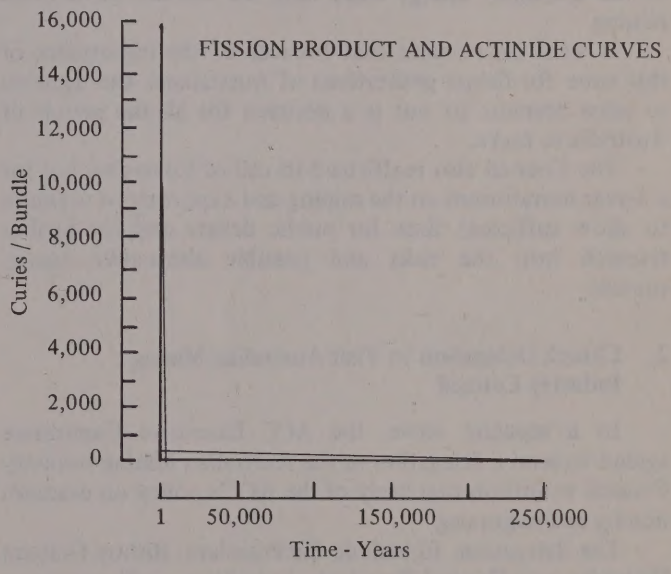
While this argument is true, does it really matter? For the amount of material involved in tooth fillings, probably not. This is, however, only one example of the many things we do which constitute a legacy. Forests are destroyed, minerals are extracted, toxic heavy metals are extracted, concentrated and then widely dispersed, fossil fuels are burnt and their combustion gases released to the atmosphere. Everywhere the hand of man is vile. In a different vein, a commitment to intensive agriculture is a commitment for all future generations because we now have a society utterly dependent on it. We have accepted all these things in the past because we didn't think about them. The radioactive case really does make us think. It is, however, one instance where we can, very effectively, minimize environmental effects. The judgement on nuclear power and hence on uranium mining, has then to be made in the general context of all environmental effects of all energy processes.

I and my colleagues have been reviewing the potential of all energy related technologies in the context of a fifty year planning horizon. We see that we in Canada – and more importantly, we in the world – are going to have to develop every possible source of energy; nuclear energy being only one, albeit an important one. We find that almost all of them have unresolved and unquantified environmental questions associated with them. For Canada, this is particularly true of tar sands developments and all northern energy developments. It is true for all foreseen developments placing an increased reliance on coal, and of course for nuclear energy, the concern of this Commission.

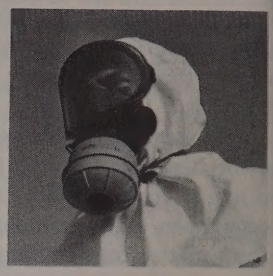
More specifically, if we look at methods of producing high grade energy (energy at temperatures greater than 1000C) the only two immediate options are coal and nuclear energy. Each of these has unresolved environmental concerns associated with it. One cannot say that the long term problems associated with coal are less than those with nuclear energy; only that they are different. For coal we are concerned with the release of non-radioactive carcinogens, of lung irritants and of CO_2 whose accummulation in the atmosphere could lead to climatic changes. It is extremely important then, that judgements on the advisability of developing nuclear power be judged in this wider context.

Figure 1

ILLUSTRATION OF THE CHANGING NATURE OF NUCLEAR WASTES



VII. THE POSITION OF THE EXECUTIVE COMMITTEE OF THE AUSTRALIAN COUNCIL OF CHURCHES ON URANIUM MINING



1. Uranium Mining – A Decision for all the People of Australia

The Executive Committee of the Australian Council of Churches has expressed the opinion that no adequate case has yet been presented to the Australian people justifying haste in reaching a decision about the mining and export of uranium.

Meeting in Sydney on July 13 (1977), the Council Executive acknowledged that there are clearly marked divisions in the Australian community, both over the nature of the so-called "energy crisis" and the wisdom of uranium mining.

It went on to state that because of the importance of this issue for future generations of Australians, the decision to mine uranium or not is a decision for all the people of Australia to make.

The Council also reaffirmed its call of November last for a 5-year moratorium on the mining and exporting of uranium to allow sufficient time for public debate and for further research into the risks and possible alternative energy sources.

2. Church Delegation to Visit Australian Mining Industry Council

In a separate move, the ACC Executive Committee agreed to send a delegation to the Australian Mining Industry Council to inform that body of the ACC's policy on uranium mining and exporting.

The delegation, to include the President, Bishop Graham Delbridge and General Secretary, Jean Skuse, will suggest to the Mining Council that "the mining companies would perform a valuable service to the community if they were to offer to observe a moratorium until

a) The rights of Aboriginal Communities so affected have been safeguarded to their satisfaction.

b) Acceptable procedures exist for the safe management of radioactive waste.

c) Effective international safeguards are established to prevent the proliferation of nuclear weapons."

The ACC delegation will submit that the full public debate called for in the Ranger Uranium Environmental Inquiry Report has not yet concluded. Furthermore, the ACC believes that a decision at this stage in favour of mining and exporting uranium will provoke serious resentment among many people who consider the decision premature, and that this reaction may lead to confrontation with the mining companies.

3. Uranium and a Nuclear Society

Uranium and a Nuclear Society is the title of a new leaflet being circulated nationally by the Australian Council of Churches to encourage debate on these crucial social and ethical issues.

The eight page leaflet introduces the issues of disposal of radioactive wastes, Aboriginal Land Rights in the vicinity of uranium deposits, and nuclear weapons as well as raising questions about a plutonium economy and the social implications of nuclear energy. It is written with a church audience in mind and aims to be an introduction to the issues involved rather than a definitive statement.

Suggestions for action as well as for further reading are included and addresses of key offices in each State are listed. The leaflet is available on request from the ACC, 199 Clarence Street, Sydney.

NOVEMBER
1977 No 24

anticipation